AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 1

I. Topic: Geology

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: Draw and label a diagram of a cross-section of the earth.

III. Activity One: Mapping Plate Tectonic Activity **20 minutes**

Objectives:

a) The learner will (TLW) map major earthquake and volcanic events worldwide using a government data base.
b) TLW recognize that regions of geologic activity are indicative of plate boundaries and regions of plate tectonic movement.

Materials:

For each pair of students: one overhead transparency printed with the land masses and latitude and longitude lines; fine-point "Vis-à-vis" pens (you'll need several pens of one color for earthquakes, and several pens of a different color for volcanoes); one copy of a "Significant Earthquake Events" list and a "Significant Volcanic Events" list (which can be obtained from the www.ngdc.noaa.gov website; this is detailed below in step one). For the class: an overhead projector and screen.

Procedure:

1. Prior to class, obtain the lists of significant earthquake and volcanic eruptions worldwide: Go to www.ngdc.noaa.gov, click on "Natural Hazards," click on "Earthquake Data," then click on "Significant Earthquake Database" and conduct a search for earthquakes of a particular magnitude for a particular time frame. For instance, if you type in a date range of 1906-2006 and an earthquake magnitude of 7.8-9.9, the search yields a list of 300 earthquakes (which can be used for ten pairs of students mapping 30 events on their transparency). If you need a longer or shorter list, simply change the dates or the magnitude and click on the "Search Database" button to get a new list. To obtain a list of volcanic eruptions, click on "Volcano Data," then click on "Significant Volcanic

Eruptions Database" and conduct a search for volcanoes that occurred during the same time frame. For instance, if you type in the date range of 1906-2006, the search yields a list of 188 volcanoes (which can be used for six pairs of students mapping 30 events on their transparency). If you need a longer or shorter list, simply change the dates and click on the "Search Database" button to get a new list.

2. Give each pair of students a transparency printed with the land masses and latitude and longitude lines. Give each pair a list of earthquakes and a pen of one color or a list of volcanoes and a pen of another color.
3. Divide up the list of earthquakes and assign the divisions such that each pair of students is mapping out 30 earthquakes on their transparency map (i.e., the first pair of students will map the first 30 earthquakes on the list, the second pair will map the next 30 earthquakes on the list, etc.).
4. Divide up the list of volcanic eruptions and assign the divisions such that each pair of students is mapping out 30 volcanoes on their transparency map (i.e., the first pair of students will map the first 30 volcanoes on the list, the second pair will map the next 30 volcanoes on the list, etc.).
5. When all pairs have mapped their 30 events, stack the transparencies together to place on the overhead projector. Discuss the results using Socratic questioning:
    a. Which locations have the majority of the earthquake activity? *(The plate boundaries, such as the Pacific Rim region.)*
    b. Which locations have the majority of the volcanic activity? *(The plate boundaries, such as the Pacific Rim region.)*
    c. Are earthquake and volcanic activity related? *(Yes, the movement of lithospheric plates causes detectible activity at the earth's surface.)*
    d. Can anyone explain how volcanoes and earthquakes are related geologic events? *(Use this question to determine what your students know about this topic, to decide how much review time is needed.)*

IV. Activity Two: Introduction to Plate Tectonics 20 minutes

Objectives:

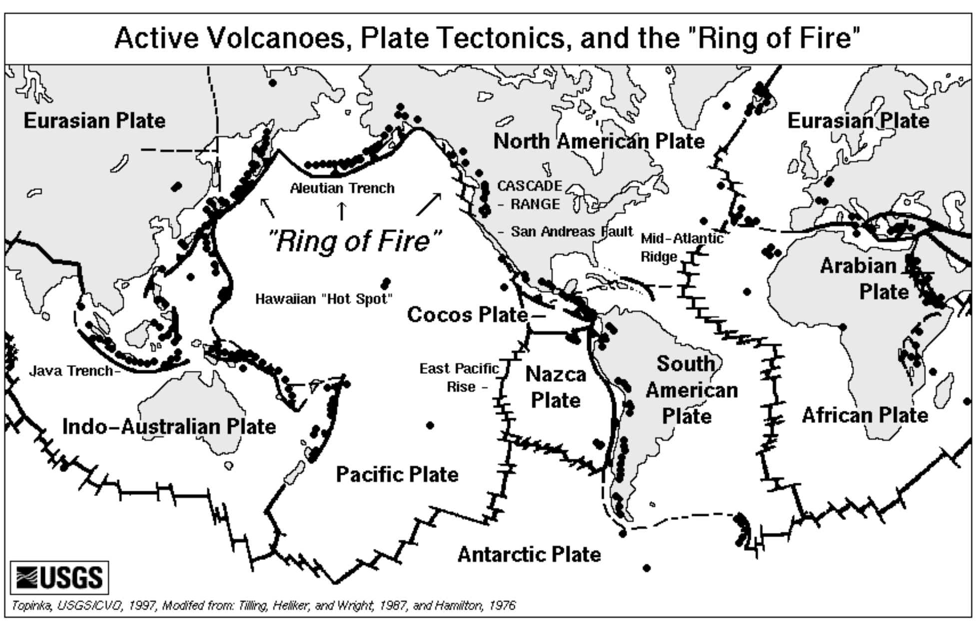
a) TLW be introduced to the structure of the inner earth and plate tectonics.
b) TLW relate the occurrence of volcanic and earthquake activity to the movement of lithospheric plates.

Materials:

For the class: a boiled egg that is cracked then dyed with vinegar and food coloring so that the cracks are obvious; and a knife.

Procedure:

1. Using the dyed, cracked boiled egg as a prop, explain how the lithosphere is composed of plates that move on a layer of mantle called the asthenosphere. Use the knife to cut the egg in half to show the students the layers of the egg and relate them to the layers of the earth. Ask the students how this model is similar and how it differs from the actual layers of the earth. *(Scientists divide the earth into five layers: inner and outer core, lower and upper mantle and the crust. Also, the layers of the earth have differences in pressure and only the inner core is thought to be completely solid.)*
2. Relate their observations on the occurrence of volcanic and earthquake activity to plate tectonics, so that the students can see the relationship between plate boundaries and geologic activity as evidence for plate movement. Here are some suggested questions to lead the students through this analysis:
    a. Considering how the cracked shell of the egg is like the plates that make up the lithosphere of the earth, does the earth's surface increase and decrease over time, according to how many segments exist? *(No. There is a finite amount of space on the surface and although the number of plates can change, the total surface area of the earth remains constant.)*
    b. If the plates are mobile, pushed by the subterranean movement of the mantel, what evidence would we see of this movement? *(The plates would have friction along their boundaries if they are going in different directions, resulting in earthquakes. Upheaval would occur if plates are moving toward one another; subduction would occur if one plate overrides another.)*



3. Have the students watch a video or video clip of plate tectonic movement to understand how the following processes occur: subduction, sea-floor spreading, uplifting, volcanic land formation, transformation, convergence and divergence.

Special note: Go to www.google.com and choose the video button to search for videos and clips that focus on a specific topic (in this case, plate tectonic movement). Or, search plate tectonics on www.google.com or www.yahoo.com to find websites with animation, slide shows and video clips. You can also buy or rent a video on plate tectonics, or visit a video streaming website such as www.unitedstreaming.com.

4. Use Socratic questions to draw out the main points:
    a. How do oceanic plates differ from continental plates? *(Oceanic plates are denser, made primarily of basalt, while continental plates are less dense and composed primarily of granite.)*
    b. How does their difference in density affect their activity? *(An oceanic plate will dive under a continental plate during subduction, but a continental plate will never dive under an oceanic plate.)*
    c. What two processes balance one another? *(The emergence of new crust in rift valleys or sea-floor spreading, and the loss of crust at subduction zones.)*
    d. What are the results of convergent boundaries? *(If two continents are involved, usually a mountain chain forms through upheaval as they collide. Or, a volcanic mountain chain may form if a continental plate causes another continental plate or an oceanic plate to subduct.)*
    e. What are the results of divergent plate boundaries? *(Rift valleys and sea-floor spreading.)*
    f. What are the results of two plates that form a transformation boundary? *(Earthquakes often occur as the plates snag then slip past one another.)*
5. Allow the students to ask questions and answer each other in a peer-teaching manner. Guide the discussion in a step-wise, logical manner, allowing the students to put together explanations based on what they already know, so that you can identify and clear up any misconceptions or inconsistencies.
6. If time allows, ask the students to make clay or modeling dough models depicting one of the processes discussed in step 4. Tell them to use three models to show before, during and after snapshots of these dynamic processes. Have them present the models to the class and ask them to explain how the crust and asthenosphere interact during the process depicted.

HW: Ask the students to bring in three rocks that they think are in three different phases of the rock cycle (remind them to consult their textbook for information about the rock cycle if they are not sure what the three phases are).

HW: Remind the students to check the year calendar for chapter reading and video assignments.

AP* Environmental Science
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Day 2

I. Topic: **Geologic Cycle**

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: Explain how an igneous rock can eventually become a sedimentary rock. Explain how a sedimentary rock can become a metamorphic rock.

III. Activity One: Transitions in the Geologic Cycle **5 minutes**

Objectives:

a) TLW relate the composition of rocks to the composition of soil.
b) TLW experience the processes rocks undergo to change physically or chemically into a different phase of the geologic cycle.

Materials:

For each student: two pieces of sandstone; one piece of marble; one small, disposable, aluminum pie dish ~10-15cm in diameter; safety goggles; one small but thick nail; one handful of clay; one sheet of wax paper (about 30x30cm); a hard tree branch or stick. Optional: other rocks that can be used in an acid rain comparison experiment: limestone, basalt, granite and shale. For each lab group: pH sticks; 50-100ml of 0.05M sulfuric acid (to serve as mock acid rain); and one hammer. For the class: one can of sweetened condensed milk; one bag of semi-sweet chocolate chips; one bag of coconut flakes; two packages of graham crackers; one stick of butter; one shallow, disposable, aluminum cooking pan about 9x9x3in.; and one hot plate.

Procedure:

1. Begin by asking the students how igneous, sedimentary and metamorphic rocks become soil. Review the concept of primary succession and help the students see its connection to the formation of soil.
2. Tell the students you would like them to make soil through physical weathering of rocks. Ask them to rub the two sandstone rocks against each other over their aluminum collection pan (pie dish) to simulate rocks tumbling against one another in a stream bed. Ask them to rub the tree

branch against the rock samples over their pie dish, to simulate the action of the wind blowing branches repeatedly against a rock. Ask them to gently tap a nail into one of the rock samples to simulate roots pressing their way through cracks in a rock to split the rock apart.

3. Ask the students if their "parent" rock has given off any particles small enough to be considered soil. Ask the students if they can think of any other ways rocks are weathered physically.
4. Ask the students to spread one half of the handful of clay in a thin layer on the middle of their sheet of wax paper. Tell them that this signifies clay found in the bottom of a pond or river bed.
5. Ask the students to sprinkle the weathered pieces of parent rock on the clay as if the particles have washed into a pond or river and have settled to the bottom.
6. Ask the students to add the other half of the handful of clay on top of the rock particles to demonstrate how the clay, the sandstone and the granite would mix as the layers settle to the bottom of the pond or river bed.
7. Tell them that the water column would add weight to the sediments and top layers would add weight to the bottom layers so the lower layers would, over time, compress into sedimentary rock.
8. Ask the students if they can think of a scenario in which this sedimentary rock could become a metamorphic or igneous rock. *(If the rock were heated by a magma plume or lifting, compression or folding of the riverbed, then the rock might become partially melted and cooled—in which case it would be a metamorphic rock. If the rock were melted completely by one of the above occurences, then the rock would be igneous.)*
9. Tell the students that they will now chemically weather the rocks. Ask them to place a piece of marble in the aluminum pie dish. Ask them to slowly drip 10ml of acid rain over the rock, keeping the dropper the same distance from the rock throughout. Allow the rock to sit in the puddle of acid rain in the same way a rock in a stream or near a pool of rain water might, and ask the students to test the pH of the acid rain sample. Allow the rocks to sit overnight, then have the students test the pH of the water in the pan the next time they come to class. (This is scheduled as the warm-up for Day 4.) If you would like, this part of the activity can be extended into a comparison of the neutralizing effects of different types of bedrock. If you are planning to do this extension, order the optional rocks listed in the materials list above and compare the pH of the acid rain water after 24 hours for each rock sample.
10. To give the students an experience that will help them remember this activity, perform a quick review of the topics and terms that have been covered so far using the foods in the materials list: Weather the graham crackers physically by rubbing and crushing them against each other above the aluminum pan, and show the students the resulting soil made from the weathering of this bedrock. Press and mix a rock of a second composition, butter, into the weathered rock to yield a mixture of

sedimentary particles. Add layers of various other weathered rocks—coconut, chocolate chips—and some clay-like adhesive material that is common in composite rocks—sweetened condensed milk. Point out that the sedimentary rock that might form from this mixture would have visible layers with parent rock from different locations due to unequal erosion of parent material from different places in the watershed. Place the pan on the hot plate and allow the sedimentary rock to move through a metamorphic phase (bake). It may be necessary to take a core sample to determine whether or not the rock has indeed reached this stage of partial melting. After the sedimentary particles have moved into a metamorphic stage, allow them to melt completely into the igneous stage at the center of the hot plate. Stir the melted center portion to demonstrate the differences in the melting temperatures of each type of rock in the composite. Explain that all particles would need to melt completely for the rock to be considered igneous, but even if the middle of the rock layer reaches that state, there may still be metamorphic rock surrounding the igneous region. Allow the students to sample the igneous and metamorphic rock (cookie) to determine if the center portions truly did enter the igneous phase.

IV. Activity Two: Make a Rock Cycle — 10 minutes

Objectives:

a) TLW identify characteristics that are used to classify igneous, sedimentary and metamorphic rocks.
b) TLW visualize the relationship between each of the phases of the rock cycle.

Materials:

For the class: ~10m of yarn (to make a circle on the floor that is divided into thirds); rock samples that show the range of properties for igneous rocks: granite, rhyolite, pumice and obsidian (optional additional rocks include gabbro, diorite and basalt); rock samples that show the range of properties for sedimentary rocks: conglomerate, sandstone, limestone and shale (optional additional rocks include those with fossils in them, which can be purchased from science supply catalogs); and rock samples that show the range of properties for metamorphic rocks: slate, gneiss and marble. Also, each student will need the three rocks they brought in for homework.

Procedure:

1. While the students are sampling the cookie, make a circle with a diameter of ~2m on the floor, using the yarn. Then use the remaining yarn to divide the circle into equal thirds (it should look like a Mercedes Benz logo).
2. Using chalk, label the three portions of the circle, "igneous," "metamorphic" and "sedimentary."
3. Once you have the students' attention, ask the students how the three labeled phases are a "cycle." After discussing the transition between each phase, check to see if your students are able to make some general comparisons:
    a. What has to happen for a rock to become a sedimentary rock? *(It must be weathered.)*
    b. What has to happen for a rock to become an igneous rock? *(It must melt completely.)*
    c. What has to happen for a rock to become a metamorphic rock? *(It must melt, but only partially.)*
    d. Can a rock from one category of the cycle go through a transition and become a different type of rock from the same category? *(Yes. For example, a volcanic rock, which is igneous, can cool and then be melted completely again when molten lava flows over it. It can then cool again to become a different type of igneous rock.)*
4. Ask the students to make some predictions about rock identification based on what they understand about the formation of each type of rock.
    a. What might be some characteristics to look for in a sedimentary rock? *(Look for particles that look like sand or gravel that has been cemented together rather than melted.)* Pass around the conglomerate, sandstone, limestone and shale, pointing out the diminishing particle size in each sample. After the students have examined these samples, place them in the sedimentary portion of the rock cycle on the floor.
    b. Does anyone have a sample that meets the description of a sedimentary rock? *(If so, pass the samples around for confirmation, then have the students add these rocks to the sedimentary section of the rock cycle on the floor.)*
    c. What types of rocks make fossils? *(Sedimentary; the others would melt the impressions left behind.)* Show the students an example of a stone with a fossil embedded in it, if you have one.
    d. What might be some characteristics to look for in an igneous rock? *(Look for a solid-colored rock that has been completely melted and that cooled quickly, or look for a rock that has medium to large crystals in it, indicating the rock cooled slowly.)* Pass around the granite, rhyolite, pumice and obsidian, pointing out the cooling rates that are evident in each of these samples. Obsidian is a smooth, glassy volcanic rock that has cooled very quickly in contrast to pumice, a volcanic rock that cooled quickly but trapped escaping gas in the process. Granite, with its medium to large crystals, is an example of an igneous rock that cooled slowly enough for crystal

formation to begin, while rhyolite is a type of granite that cooled much more quickly (but slower than obsidian or pumice), leaving little time for crystal formation and migration. After the students have examined these rocks, place them in the igneous portion of the rock cycle. (If you have the time and the desire to teach your students more about geology, you can describe the differences between igneous rocks that are rich in silica, such as the granite types, compared to the igneous rocks that are rich in ferro-magnesium minerals, the basalt types. Geology is not a topic covered on the AP Environmental Science Exam, however, it is a wonderful area in which students can practice scientific reasoning and observe scientific processes such as cycles and weathering. To aid in discussions of differences between rocks, order samples of basalt (which has the smallest crystals), diorite (which has medium crystals) and gabbro (which has the largest crystals). Basalt-type rocks also show evidence of cooling rates and typically come from shield volcanoes such as those found in Hawaii.

e. Does anyone have a sample that meets the description of an igneous rock? *(If so, have them pass the sample around for confirmation, then have them add it to the igneous section of the rock cycle on the floor.)*
f. What might be some characteristics to look for in a metamorphic rock? *(Look for layers that have been bent or folded, and the formation of large crystals that demonstrate partial melting and slow cooling.)* Show the students the sample of sedimentary rock shale, then show them the metamorphic rock that results when shale is melted—slate. Show them the sedimentary rock—limestone—then show them the metamorphic rock—marble—with larger crystals that resulted when the limestone was heated and cooled. Show the students the piece of igneous rock—granite—then show them the gneiss that results when the minerals are melted enough to allow the crystals to migrate to find like molecules (creating bands of color). After the students have examined the samples, place them in the metamorphic section of the rock cycle on the floor.
g. Does anyone have a sample that meets the description of a metamorphic rock? *(If so, have them pass the sample around for confirmation, then have them add it to the metamorphic section of the rock cycle on the floor.)*

5. Ask the students who still have rocks to pass them around the class, so other students can try to identify them. Ask the students to make hypotheses with observations to back up their ideas.

HW: Ask the students to research the General Mining Law of 1872. Ask them to write down what land can be purchased under this law, the approximate cost of the land and the conditions of the sale.

AP* Environmental Science
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Day 3

I. Topic: Soil

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: List the items that make up soil. *(Water, small particles of rock, bacteria, fungi, worms of each phyla, insects, arachnids, centipedes, millipedes, protozoa, mollusks, decomposing vegetation, decomposing organisms, ions such as Mg^+, Ca^+, $NO2^-$, $NH4^+$, K^+,$H2PO4^-$, $SO4^-$, H^+, Cu^+.)* Which item on your list comprises the largest component of soil by number? *(Bacteria.)* Which item on your list comprises the largest component of soil by weight? *(Small particles of rock.)*

III. Activity One: Soil Testing **35 minutes**

Objectives:

a) TLW observe the macroorganisms found in soil.
b) TLW test the level of nitrogen, phosphorus, potassium and pH in several soil samples and predict what biotic organisms are present in this soil.
c) TLW design a method to test drainage rates, particle size or water-holding capacity of a soil sample.

Materials:

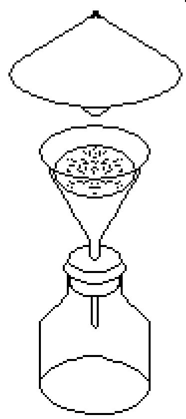
For the class: four or more cookie sheets or other large sturdy containers to hold soil samples; and a shovel. For each lab group: one soil chemical analysis kit to test pH, nitrogen, phosphorus and potassium content of soil; one Berlese Apparatus (or make your own using a large funnel; a large jar or beaker; one 20cm x 20cm piece of window screen; a lamp with an incandescent bulb; and aluminum foil). For each student: one dissection microscope or stereomicroscope; one Petrie dish; one pair of tweezers; one copy of the “Common Soil Organisms” handout.

Procedure:

1. Prior to class, obtain two soil samples from two or more different biomes (the ideal would be to obtain samples from the quadrants you studied

earlier this year). The first sample will be used to demonstrate the layers of soil—the soil horizons—so, the sample should be kept intact, as a cut-out of the soil composition exactly as it would appear underground. To obtain this sample, press a shovel firmly into the ground, then push down on the shovel handle until the sample comes out of the ground resting on the blade of the shovel. Hold the cookie sheet or other container against the sample and gently turn the sample over, onto or into the container, so that the O layer (vegetation, leaf litter), the A horizon (topsoil with decomposing organic matter and broken-down rock particles), the B horizon (larger rock pieces; the less weathered layer) and possibly the C horizon (bed rock or parent rock layer) are all visible.

2. The second sample will be used to collect soil macroinvertebrates, so it is fine if this sample falls apart or is not as deep. For this sample, you'll want to collect some of the O and A horizons where the majority of the macroinvertebrates can be found. Bring this sample back to the classroom and set up one Berlese Apparatus for each lab group.



   You can make inexpensive macroinvertebrate collectors by filling large funnels, or tops cut off of milk jugs, with a piece of window screen pressed down into the funnel opening. Place the funnel over a large beaker or empty glass jar and add the soil sample to the funnel. Be sure to get some soil from both the O horizon and the A horizon (you may want to set up two different collectors to compare the organisms in these two layers). Place an incandescent lamp close (but not too close!) to the soil sample, to drive the macroinvertebrates to the bottom of the funnel. Place several drops of water into the beaker or collection jar and cover the opening with aluminum foil, so the invertebrates do not dry out. If you have soil samples from different biomes, you will want to set up separate macroinvertebrate collectors for each, so the students can compare macroinvertebrate compositions.

3. Begin by discussing the warm-up. Tell your students that one teaspoon of soil contains more than 5 billion bacteria, and thousands of other organisms such as protozoans, fungi and macroinvertebrates.
4. Ask a student to look at the soil horizons of the samples you have collected. Ask if anyone can name the layers and describe the physical,

chemical and biological characteristics of each layer. If they are struggling, ask them questions that guide them through what they already know so that they can then hypothesize about what they don't know for certain.

5. Ask the students to each get a stereomicroscope, a Petrie dish and a pair of tweezers.
6. Distribute the "Common Soil Organisms" handout. If you have samples from two different biomes, assign one half of the class a Berlese funnel from one of the two soil samples, while the other half of the class inspects the macroinvertebrates from the second soil sample. There is a soil organism identification diagram on the handout. However, you may also want to show color photographs or a color diagram of soil organisms on a projector as a second identification source.
7. Ask the students to keep track of the diversity and abundance of each of the macroinvertebrates found in the samples on the data sheet provided.
8. Encourage a class discussion of the macroinvertebrate data and allow the students to draw some conclusions.
9. Use soil test kits to discover the pH, nitrogen, phosphorus and potassium content of each soil sample. Analyze the data and draw some conclusions. Ask your students what other experiments and soil tests might be interesting to conduct with these two samples. Tell the class that they will design a lab experiment to perform on these samples during tomorrow's class.
10. Assign each lab group a topic from the list below or allow the groups to each choose a topic (these topics are related to one another so the experiment results for some of the tests should also be related):

    Pore size
    Texture
    Drainage rate
    Water retention
    Particle size

11. Give the lab groups time to design a test that suits their topic. Remind them to keep the procedure within the time and equipment limits of the laboratory.
12. Check that each lab group has the materials they will need to conduct their experiment or help them collect supplies before tomorrow's class.

IV. Activity Two: The General Mining Law of 1872 10 minutes

<u>Objectives</u>:

a) TLW communicate what they have discovered in their research.
b) TLW formulate and defend their personal opinion of this law.

Methods:

The students will need their homework from last night (research of the General Mining Law of 1872).

Procedure:

1. Discuss what your students have found out about the General Mining Law of 1872. Ask several questions to see how much they understand about the application and results of this law:
    a. Why was this law passed originally? *(To encourage westward expansion and resource extraction on public lands.)*
    b. What land is available for purchase under this law (through patenting)? *(All public lands: National Forests, U.S. Fish and Wildlife Reserves, National Monuments, Bureau of Land Management lands, etc., except wilderness areas and national parks.)*
    c. What are the terms of the sale of this land? *(The purchaser—an individual or a company—must declare that they believe the land has hard rock mineral resources or petroleum products in it, must spend at least $500 to improve the land, must file a claim with an annual $100 fee, and pay $2.50-$5.00 per acre for the land.)*
    d. How much land can be purchased? *(There is no limit.)*
    e. Who most commonly uses this law to purchase land? *(Mineral or petroleum mining companies. The mineral companies are most often from other countries, such as Canada and Australia.)*
    f. Who owns the land that is bought under this law? *(You do—the public lands of the United States are owned by all citizens of the U.S.)*
    g. Who owns the resources found in the ground or water on the land bought under this law? *(The resources found on public lands in the United States are also under joint ownership of all the people in the U.S.)*
    h. Who gets the money from the sale of the resources found on this land? *(The mining company that has made the hard rock mineral claim gets 100% of the profits—totaling $2-3 billion dollars per year—while petroleum extraction companies must pay 8-16% royalties on the net value of the resources they extract.)*
    i. What damage control and rehabilitation is required on the land that is purchased? *(None is required.)*
    j. What are the arguments for maintaining this law? *(Mining companies claim that the price of exploration, setting up and extraction is so costly that it would not be profitable to extract resources in the U.S. if they had to pay a fair price for the land or if they had to pay for cleanup costs.)*

k. What are the estimated cleanup costs for extractions performed on these public lands? *(There are currently 557,000 mines in the U.S., with an estimated cleanup cost of $33-72 billion.)*

2. Let your students know that environmental groups have worked for years to change this law because they feel it is no longer serving its original purpose. Ask the students if they think the law should be repealed, modified or allowed to remain as is. Require the students to support their opinions with scientific reasoning.

HW: Ask the students to type up their soil lab experiment on a computer, being sure to include the question, hypothesis (or hypotheses), the null hypothesis, the materials list and the procedure. They will add their data and conclusions to this document after they conduct their lab. The finished document will be due by the end of the week.

Common Soil Organisms

Below is a diagram of some common soil organisms and their trophic level in a food web.

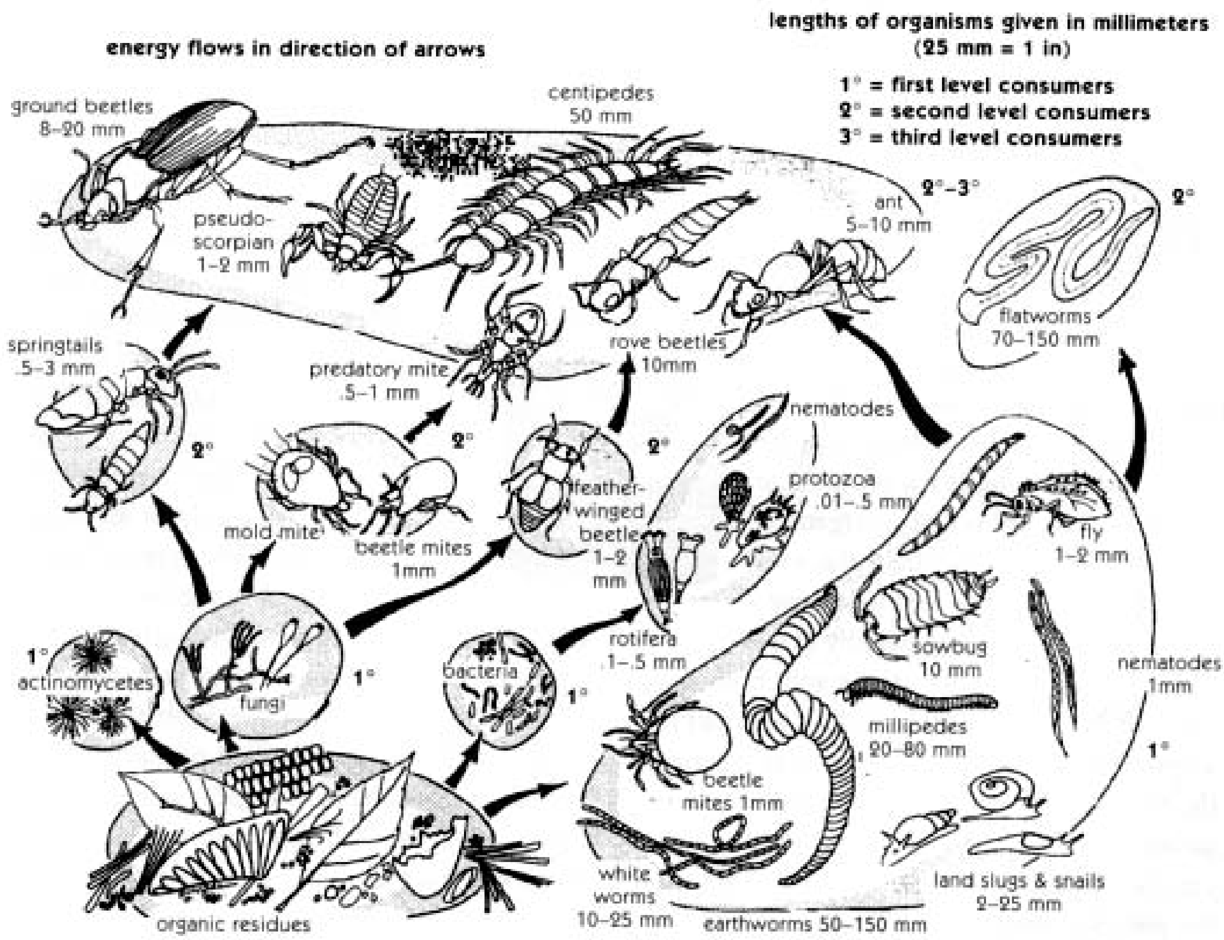


Figure 3.1 Soil organisms and their role in decomposing residues. Modified from D.L.Dindal, 1978.

AP* Environmental Science
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Resources and Energy Unit

Day 4

I. Topic: Soil Testing

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Swirl the water in your rock pan, then test the pH. Has it gone up or down? Explain why the change occurred. *(The acid rain water dissolved some of the minerals in the rock and the minerals used some of the hydrogen ions from the water in the pan to stabilize these free molecules.)* When you're finished, take the reading quiz.

III. Activity One: *When Smoke Ran Like Water* - Ch. 3 Quiz 15 minutes

Objectives:

a) TLW demonstrate what they have retained from the Davis book.
b) TLW express and generate interest in the book they are reading.
c) TLW make connections between the examples given in the Davis book and what they are learning in their textbook and class.

Materials:

For each student: a copy of the quiz.

Procedure:

1. Allow the students 5-6 minutes to complete the reading quiz.
2. Ask the students to trade papers with someone who has a different color pen.
3. Go over each question, allowing the students to provide answers and discuss the book, in order to build interest in it and to make connections to topics covered in class and in the textbook.

IV. Activity Two: Student-designed Soil Experiments 30 minutes

Objectives:

a) TLW understand the terms and processes related to soil properties.
b) TLW be able to design and carry out an experiment that addresses a specific question.

c) TLW analyze their data to draw conclusions.

Materials:

The materials needed will vary according to the experiments the students designed yesterday during class. For the class: a copy of Free Response question #4 from the 2004 AP Environmental Science Exam (to be assigned for homework, below). All past AP Exam Free Response essay questions and grading rubrics can be found at the www.apcentral.collegeboard.com website. Sign in, then choose the title "Exam Questions" that appears when you roll over the green button that says "AP Courses and Exams". Simply click "Environmental Science" on the "Exam Questions" page to find the FR questions for past exams.

Procedure:

1. Spend a few minutes discussing the acid rain lab results in the warm-up. Ask the students how these results could be used to predict how the parent rock of a particular soil might react with acid deposition. Press them to conclude that regions with acid deposition and bedrock that has neutralizing capabilities will have healthier surface waters and richer soils compared to regions with acid deposition and inert bedrock. Ask the students what solutions they would propose for treating rivers and lakes with a low pH.
2. Allow the students to begin conducting the soil experiments they designed.
3. After all the experiments have been performed, ask the lab groups to clean up and then write 3-5 conclusions based on their data.
4. Ask each lab group to add the data and conclusions to the lab design they typed up for last night's homework. Tell them to email a copy of their design with the added data and conclusions to you by tomorrow night.
5. When you receive the lab summaries and conclusions, print or send a copy to each student in the class so that everyone can benefit from the experiments conducted by each lab group.

HW: Ask the students to write an essay for Free Response question #4 from the 2004 AP Environmental Science Exam.

HW: Ask the students how their crystals are coming along. Plan a time when they can bring the crystals to class, so that the best ones can be chosen for an award.

When Smoke Ran Like Water by Devra Davis
Ch. 3 - "How to Become a Statistic"

1. What does Davis say about low levels of toxins that fall below the "threshold levels"?

2. Give two specific reasons described in this chapter that explain why air pollution affects adults and children differently.

3. How do indoor and outdoor air compare for toxicity (such as a car in traffic, or a house compared to its backyard)?

4. What did car and gasoline companies GM, Goodyear, Standard Oil, Phillips Petroleum, Firestone Tire and Rubber, and Mack Truck conspire to and successfully pull off in Los Angeles between 1930 and 1950?

5. Why was lead originally added to gasoline and why wasn't ethanol used instead?

6. Mary Amdur argued that it was not just the dose that made the poison, it was also what factor?

7. Which did Amdur find to be more detrimental in her air pollution experiments with Guinea pigs: a small dose for a prolonged period of time or a large dose for a short period of time?

8. Philip Drinker, who supervised Mary Amdur's research, was funded by a company that was a large producer of sulfuric acid (ASARCO). When Amdur tested sulfuric acid and realized how detrimental the effects were on her test subjects, what did she do with the results and what occurred because of her actions?

9. Name three of the top six air pollutants (the same pollutants regulated throughout the U.S. by the Clean Air Act).

10. Explain how California become the leading state in the research and development of air pollution testing, laws and regulation?

When Smoke Ran Like Water by Devra Davis
Ch. 3 - "How to Become a Statistic"

Teacher's Version

1. What does Davis say about low levels of toxins that fall below the "threshold levels"? *They are just as harmful and there is no dose level that does not affect an organism.*
2. Give two specific reasons described in this chapter that explain why air pollution affects adults and children differently. *Children are at the level of exhaust pipes, they are more active, they take more breaths per day, they have a greater lung-surface-area-to-body-size ratio and thus have a greater concentration of pollutants per gram of body mass.*
3. How do indoor and outdoor air compare for toxicity (such as a car in traffic, or a house compared to its backyard)? *Indoor air is 10x more polluted than outdoor air.*
4. What did the car and gasoline companies GM, Goodyear, Standard Oil, Phillips Petroleum, Firestone Tire and Rubber, and Mack Truck conspire to and successfully pull off in Los Angeles between 1930 and 1950? *They removed public transportation from L.A.*
5. Why was lead originally added to gasoline and why wasn't ethanol used instead? *To keep car engines from making a pinging noise (not a mechanical problem). Ethanol worked just as well, but it was not possible to patent it and make money.*
6. Mary Amdur argued that it was not just the dose that made the poison, it was also what factor? *The age of the subject (the young are affected more than adults).*

7. Which did Amdur find to be more detrimental in her air pollution experiments with Guinea pigs: a small dose for a prolonged period of time, or a large dose for a short period of time? *Long term exposure.*

8. Philip Drinker, who supervised Mary Amdur's research, was funded by a company that was a large producer of sulfuric acid (ASARCO). When Amdur tested sulfuric acid and realized how detrimental the effects were on her test subjects, what did she do with the results and what occurred because of her actions? *At a meeting in Chicago for Amer. Indust. Hygiene Assoc., she was accosted in the elevator by men who threatened her and told her not to present her findings. She did anyway, and Drinker ordered his name removed from her papers.*

9. Name three of the top six air pollutants (the same pollutants regulated throughout the U.S. by the Clean Air Act). *Answers should consist of three from the following list: sulfur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O_3), particulate matter, lead (Pb).*

10. Explain how California become the leading state in the research and development of air pollution testing, laws and regulation? *The state had an inversion problem so it accumulated air pollutants, it attracted people for its sunny skies and climate, had too many cars and a governor who wanted the air cleaner to maintain the economy (he did not want to turn off people/industry), so he supported research and change to improve air quality.*

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 5 - Extended Lab Period

I. Topic: Household Energy Consumption

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Check the Winogradsky column. Draw a sketch of the column, depicting each colored layer at its approximate distance from the top and bottom of the column. Measure and record the exact thickness of each layer and its distance from the top or bottom of the column.

III. Activity One: Grade a FR Essay as a Lab Group 15 minutes

Objectives:

a) TLW grade FR essays to see how the details and facts included in the essays compare to those in the grading rubric.
b) TLW see how their work compares to their peers' and to the grading rubric.

Materials:

Each student will need their completed 2004 FR essay #4; a pen of another color; and one copy of the grading rubric for this essay (which can be obtained from the www.apcentral.collegeboard.com website).

Procedure:

1. Collect all the essays and ask the students to divide into lab groups. Redistribute the essays, making sure that no lab group is grading a member's paper.
2. Distribute the grading rubric and ask the students to go over it with their lab group before they begin grading.
3. While grading, the students are to write points earned in the left-hand margin and underline the word, phrase or sentence that earned the points.
4. When a student has finished grading an essay, they are to pass it to another person in their lab group and move on to another essay, until all the essays have been read and graded by each person in the lab group. The group must discuss any discrepancies in the number of points

assigned to a section(s) until they arrive at a consensus. They must then write the final score next to the section and compute the grade.

5. When they have finished, ask the students to write their names on the bottom of each essay and turn them in to you for review.

IV. Activity Two: Measuring Energy Consumption 70 minutes

Objectives:

a) TLW predict the energy consumption of common household appliances.
b) TLW measure and record the actual energy consumption of common household appliances.
c) TLW calculate the amount of coal needed to run the appliances in their home each year.

Materials:

For the class: one Kill-A-Watt power meter or other device that measures kilowatt hours easily (or, use the “Wattage of Common Household Appliances” handout that has been provided for you following this lesson plan); several household appliances and devices that plug in—the ideal collection would include a microwave, a refrigerator, a dishwasher, a phone charger, an iPod charger, a laptop computer, an alarm clock, a portable stereo, a fan, a lamp, a washer, a dryer, a TV, a toaster oven, a hair dryer, an electric razor, an oven, an electric stove, an air conditioner, an electric hot water heater (read the tag), and DVD player. For each student: one copy of the “Household Energy Consumption” handout; and two different color pens.

Procedure:

1. Prior to class, look for plug-in appliances on campus that are of the size normally found in a house. Check the teacher’s lounge or cafeteria for kitchen appliances; check the gym or nurse’s office for a washer and dryer; and collect lamps, fans and other devices so that your students can discover the power usage of the most common household items. If you cannot find some of these appliances on campus, or if it is not possible for your students to visit the locations that feature these appliances, take measurements from the appliances at your house and share them with the class.
2. Distribute the “Household Energy Consumption” handout. Ask the class to predict the energy usage of the common household appliances listed, ranking each on a scale of 1-5 (one representing low energy use, 5 representing high energy use).

3. Ask the students to place three stars by the appliance they think uses the least amount of energy, two stars by the second lowest, one star next to the third lowest. Ask them to place three exclamation points next to the appliance they think uses the most electricity, two exclamation points next to the appliance they think is the second most consumptive and one exclamation point next to the appliance they think is the third most consumptive.
4. Discuss their hypotheses and allow the students to defend their choices and rankings to you and their peers. Listen carefully to your students' reasoning, it will help you discover what they do and do not understand about electricity. You will want to help alter misconceptions and fill in missing information as you work through the rest of this unit.
5. Test their hypotheses by plugging each appliance or device into the Kill-A-Watt device and telling the students the quantitative amount of electricity use per hour. You may now need to take the class on a walking tour to obtain readings from appliances you located on campus, or you may now share the readings taken from appliances at your house.
6. After all the appliances have been tested, ask the students to add to the list five or more appliances that they regularly use that would need to be plugged into an electrical outlet.
7. Ask the students to bring these appliances in when possible, so that their kilowatt usage can be measured and recorded for use in a project that'll be assigned later in this unit.
8. Ask the students to write the amount of hours this appliance or device is used per week in the column next to the kilowatt-hours reading.
9. Ask the students to calculate the approximate number of kilowatt-hours used to run each appliance for one year.
10. Tell the students that approximately 1/2 a kilogram of coal is needed to generate one kilowatt-hour. For each appliance on their list, ask the students to use the kilowatt-hours to compute the approximate amount of coal needed to generate an equivalent amount of electricity to run the appliance for one year.

HW: Ask the students to finish their soil lab experiments and send their final version of the question, hypotheses, materials, procedure, data and conclusions to you to be graded and sent out to other students.

HW: Remind the students to bring in electrical appliances or devices for kilowatt-hour measurements.

HW: Tell the students they will need to bring the following information to class tomorrow:

- ✓ The liter capacity of the engine in each car their family possesses.
- ✓ The number of miles driven per year for each car their family possesses.

- ✓ The number of miles the family traveled each year by train or bus.
- ✓ All the electricity, oil, coal and gas bills for their household for the past year.

Household Energy Consumption

Procedure:

1. On the back of this handout, rank each common household appliance listed according to the amount of energy you think it uses. Fill in the second column with the numbers 1-5 (one representing a very low amount of energy, and five representing a large amount of energy).
2. Fill in the third column with 1-3 exclamation points to indicate the top three energy-consuming appliances and 1-3 stars to indicate the lowest three energy-consuming appliances.
3. Fill in the fourth column with the measured number of kilowatt-hours used by this appliance.
4. In the fifth column, write the number of hours each week that this appliance is used (by you, or by someone using the appliance to take care of you).
5. In the sixth column, calculate the number of hours this appliance is used each year (by you, or by someone using the appliance to take care of you).
6. In the seventh column, calculate the amount of coal needed to run this appliance for a year at the rate you have given in the previous column.
7. When you have finished, list other appliances you use on a weekly basis:

Other appliances I use weekly:	Rating	Ranking	Kilowatt-hours	Hours of weekly use	Hours of annual use	Coal needed for use
Total kilowatt-hours and coal you use annually:						

Data:

Common household appliances	Rating	Ranking	Kilowatt-hours	Hours of weekly use	Hours of annual use	Coal needed for use
Laptop computer						
Phone charger						
Stereo						
iPod charger						
TV						
Alarm clock						
Fan						
Air conditioner						
Oven						
Toaster oven						
Stove top						
Microwave						
Refrigerator						
Dishwasher						
Clothes dryer						
Electric hot water heater						
Hair dryer						
Electric razor						
Light bulb						

Wattage Demands of Common Household Appliances

Appliance	Typical Wattage	Appliance	Typical Wattage
Air Conditioner (12,000 BTU)	1500	Heater (Auto Engine, Winter)	1000
Air Conditioner (5,000 BTU)	700	Heater (Portable)	1500
Auto Engine Heater	600	Heating System (Warm Air Fan)	312
Battery Charger (Car)	150	Humidifier (Winter)	177
Blender	385	Iron	1000
Bug Zapper	40	Jacuzzi (Maintains Temperature, 2-Person)	1500
CD, Tape, Radio, Receiver System	250	Lighting (Incandescent)	75
Clock	3	Lighting (Fluorescent)	40
Clothes Dryer	5000	Lighting (Compact Fluorescent)	18
Coffee Maker (Auto Drip)	1165	Lighting (Outdoor Floor)	120
Compactor, Trash	400	Microwave Oven	1500
Computer (with Monitor and Printer)	365	Mixer, Hand	100
Convection Oven	1500	Motor (1 HP)	1000
Curling Iron	1500	Power Tools (Circular Saw)	1800
Dehumidifier (20 Pints, Summer)	450	Radio	71
Dishwasher (Dry Cycle)	1200	Range (Oven)	2660
Dishwasher (Wash Cycle)	200	Range (Self-cleaning Style)	2500
Kitchen Sink Waste Disposer	420	Refrigerator/Freezer (Frostfree,17.5cu.ft.)	450
Electric Blanket	175	Satellite Dish (Including Receiver)	360
Fan (Attic)	400	Sump Pump (1/2 HP)	500
Fan (Ceiling)	80	Television (Color, Solid State)	200
Freezer (Automatic Defrost, 15 cu. ft.)	440	Toaster	1400
Freezer (Manual Defrost, 15 cu. ft.)	350	Vacuum Cleaner	1560
Fry Pan (Plug-in Skillet Type)	1200	VCR 45	45.0
Garage Door Opener	350	Waffle Iron	1200
Hair Dryer (Handheld)	1000	Washer (Automatic)	512
Heat Lamp	250	Waterbed Heater (Queen Size)	375
Heat Tape (30ft., Winter)	180	Water Heater (Quick Recovery)	4500

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 6

I. Topics: Global Energy Use

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Test the kilowatt-hour usage of the appliances or devices you brought from home. Then answer the following question: Name the top five countries that have the highest annual per capita energy usage.

III. Activity One: Who's Using Watt? 15 minutes

Objectives:

a) TLW predict the energy consumption per capita of several countries.
b) TLW determine the factors that influence a country's energy use.

Materials:

For the class: Enough name tags to allow one for each student.

Procedure:

1. Prior to class, make name tags of various countries that your students would find familiar. You'll want to choose countries that use varying amounts of energy.
2. Give each student a country name tag (or let them choose).
3. Ask the students to take a few minutes to line up according to the estimated average energy consumption per capita of each country. Countries with the highest per capita energy consumption should be closest to the front of the classroom.
4. Ask the students to justify their arrangement. Allow a discussion, which will help you identify their misconceptions.
5. With some drama, go to each student and tell them the per capita energy consumption of "their" country (the one on their name tag). Allow each student, upon learning their consumption rate, to move elsewhere in the line, if justified.
6. Ask the students why the consumption rates of the countries they listed in their response to the warm-up are lower or higher than predicted.

7. Ask the students what factors affect energy consumption in a country (wealth, disposable income, availability of consumer goods, availability of electricity, societal norms/culture, etc.).

IV. Activity Three: Calculate Your Carbon Footprint 15 minutes

Objectives:

a) TLW calculate their carbon footprint based on the things they do in a typical day, week and year.
b) TLW consider how their energy use affects global warming and the per capita energy consumption of the United States.

Materials:

For each student: a computer with Internet access; and the materials they gathered for last night's homework.

Procedure:

1. Ask the students to go to the following website once they are on the Internet: http://www.carbonfootprint.com/. (You can also check out other sites, such as the EPA website which gives emission in pounds per year: http://www.epa.gov/climatechange/emissions/ind_calculator.html. Or go to a site that gives a more detailed measurement, in tonnes per year, such as http://www.zerofootprintoffsets.com/calculator.aspx.)
2. Ask the students to then click on the yellow button that says, "Calculate Your Carbon Footprint."
3. The page will be set up for British measurements, so the students must press the U.S. flag in the upper righthand corner to reset the page for U.S. measurements.
4. Using the materials they collected for last night's homework, the students can enter the information requested. (You may need to teach the class how to read an electricity bill.)
5. After the students have pressed the "Calculate" button, ask them to compare their personal share of carbon (in kg).
6. Check the students' understanding of the data by asking some discussion questions:
    a. How are primary and secondary carbon footprints different? *(The secondary footprint reflects purchases of goods and services provided by another party—you did not create the carbon emissions that resulted from these goods and services, but by purchasing the goods and services, you take responsibility for their emissions.)*
    b. What category has the greatest impact? *(Answers will vary.)*
    c. Are your emissions greater than or less than the average per capita emissions for an industrial nation? *(Answers will vary.)*

d. Are your emissions greater than or less than the world average? *(Answers will vary.)*
e. If the average for industrial nations is 11,000 kg/year and the worldwide average is 4,000 kg/year, what does that tell you about the emissions per capita for most people in the world? *(In order for the worldwide average to be so much lower than the industrial nations' average, there must be a great number of people producing a significantly smaller portion of carbon emissions.)*
f. What specific changes could you make to decrease your average emissions? *(Answers will vary.)*
g. How could you get below the 2,000 kg/year goal?

V. Activity Three: Non-renewable Energy Debate — 15 minutes

Objectives:

a) TLW research the pros and cons of each type of non-renewable fuel used to generate electricity.
b) TLW be able to articulate what they have learned in a debate.

Materials:

(None.)

Procedure:

1. Tell the students that they will be debating use of non-renewable resources next week.
2. Ask the students to each pick a resource that they would like to back for the debate: oil, natural gas, coal or nuclear energy.
3. Allow the students to divide into debate teams and plan their research efforts. Ask them to divide the topics that need to be researched equally among the members of their team. Each team must know the cons, or "attacking" points, for each of the four fuels in the debate. Each team must know pros, or strengths/rebuttal arguments, for their own fuel.

HW: Ask the students to begin their preparation for the non-renewable energy resources debate.

HW: Ask the students to draw and label a diagram of how electricity is generated using a coal-fired power plant.

HW: Remind the students to continue to bring in any electrical appliances for kilowatt-hour measurements.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 7

I. Topic: Organic-based Deposits

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Explain how coal, oil or natural gas deposits are made. *(Organic matter such as dead plants or animals are present on the surface of the soil or in a waterway. The organic matter is covered in sediment and remains under heat and pressure in the layers of the soil and rock for hundreds of millions of years. As the organic matter decomposes, hydrocarbon chains are left behind as a source of fossil fuel.)*

III. Activity One: Mining for Oil, Gas and Coal 40 minutes

Objectives:

a) TLW familiarize themselves with the different methods of fossil fuel mining.
b) TLW simulate the extraction of oil from beneath the earth's surface.

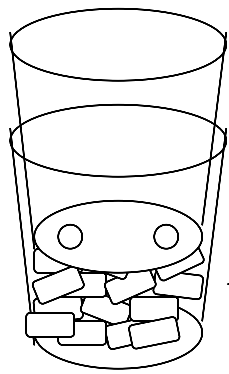
Materials:

For each pair of students: two 8-oz. clear plastic cups; a straw; water dyed with food coloring; 1 cup of dried beans (dark red kidney beans are best); a funnel that fits into the straw; approximately 4-6 oz. of vegetable oil; a metal skewer; and a lighter.

Procedure:

1. Prior to class, prepare one of the following for each pair of students: Fill an 8-oz. plastic cup about 1/2 full of beans. Add enough vegetable oil to each cup such that the oil fills in the spaces between the beans and stops at the surface of the beans.
2. Also, prior to class, prepare one of the following for each pair of students: Heat a metal skewer to melt two holes on opposite sides of the bottom of an empty 8-oz. plastic cup. The holes should be the size of the diameter of the straw you will be using.
3. You should now have a pair of cups for each pair of students: One cup with two holes in the bottom of it, and one cup with no holes that contains

the beans and vegetable oil. Place the cup that has holes in the bottom of it on top of the beans and oil, so that the holed cup is nested inside the un-holed cup and is pressing down on the beans.



4. Begin this activity by discussing the warm-up. If some of your students are unsure how fossil fuels formed in the earth's crust, allow students who are knowledgeable about the process to tutor their peers. After they have reviewed the key concepts, ask the students if fossil fuels are a renewable or non-renewable resource. This is a great time to clarify the meaning of "non-renewable"—push your students to give you a clear idea of how short the replacement process must be in order for something to be considered renewable. *(In order to be considered renewable, an item must be replaceable within the timeframe of its use.)* This would also be a good time to review the meaning of "sustainable." *(It means that something can be maintained at a certain level indefinitely.)*
5. Let the students know that approximately 86% of all human-produced energy comes from the burning of fossil fuels. Fossil fuel combustion accounts for about 6.3% of the total carbon dioxide emissions each year.
6. Ask the students to form pairs and give each a prepared cup of beans and oil with the second cup nested inside, a straw (that will fit into one of the holes in the bottom of the nested cup), a funnel (that will fit inside the straw) and a beaker of colored water.
7. Explain to the students that this set-up represents oil (represented by the vegetable oil) found underground in a layer of rocks (represented by the beans). Their job is to extract the greatest amount of pure oil without tilting the cup (since that would mean tilting the planet).
8. Allow the students to experiment, discuss with their peers and go through the process of discovering the best extraction method on their own. Observe and record their problem-solving process, jotting down observations for the discussion that will follow.
9. Eventually one or more of the student pairs will realize that oil is less dense than water, and that they can use the straw to force water into the ground, which will allow the lighter oil to seep out of the second hole on its own in a pure form.

10. You can compare the quantities of oil obtained by the students and discuss techniques used. Be sure to go over the thinking, discussion and planning processes you observed—which pairs acted before thinking, which pairs were too cautious to experiment, etc.
11. Discuss the safety concerns, environmental impacts and economic feasibility of extracting oil, using this extraction method as an example.

HW: Ask the students to research other methods of oil extraction and write the pros and cons of each method according to safety concerns, environmental impacts and economic feasibility.

HW: Ask the students to continue preparing for the non-renewable energy resources debate.

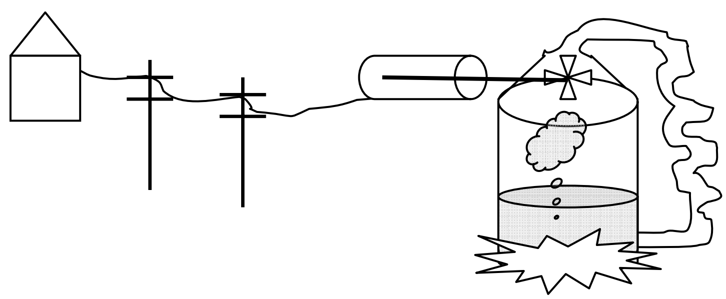
AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 8

I. Topic: Coal-fired Power Plants

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: Draw a diagram of how a coal-fired power plant works.



A simple way to explain how electricity is generated by heat (from the burning of any type of fossil fuel, or from a nuclear reaction) is by using a diagram of a pot of water on a fire. As the water boils and turns to steam, a cap with only one outlet confines the pressure. A fan (or turbine) placed in the outlet pipe will turn as the steam escapes. The fan has a central, magnetized rod that turns inside a copper wire to generate electricity which flows out a line to (transformers and then to) houses. The steam is directed through a pipe bathed in cold water to cool the hot steam. The steam condenses and is returned to the bottom of the pot to repeat the process. The smoke and ash from the fire under the pot must be cleaned (using various types of scrubbers) and sent out through a smokestack.

III. Activity One: Coal-fired Power Plant Game **45 minutes**

<u>Objectives:</u>

a) TLW pretend to own and successfully operate a coal-fired power plant.
b) TLW discover how to minimize sulfur emissions from their coal-fired power plant.

<u>Materials:</u>

For each student, the following game pieces (from the handouts that follow this lesson plan): one coal-fired power plant ownership card; 5 sulfur permits cards; one coal fuel card (there should only be enough fuel cards to allow one per student, and the cards should not all be of the same type—there should be an approximately equal number of cards for each fuel type); three technology upgrade cards; one crushed limestone card; one natural gas card; one copy of the "Sulfur Emissions Permit Exchange Program" record sheet; and $20,000,000 in fake money (you can buy fake game money in a toy store and convert it to the amount you want by adding zeroes to the bill denominations). For the class: a game bank with a balance equaling about $10,000,000 per player; and a copy of Free Response question #2 from the 2004 APES Exam and question #1 from the 2000 APES Exam (which can be obtained from www.apcentral.collegeboard.com), to be assigned as homework, below.

Procedure:

1. Prior to class, make copies of the game cards on different colors of cardstock paper such that all cards of a single type are in a single color. Cut all of the cards out along the dotted lines. Realize that you will not pass any of these cards out to your students, except for the sulfur permits, because some players will choose to buy more cards of a particular type than others (while other students will buy none of a particular card type). Some cards will be in higher demand than others—this is part of the game. But if you follow the guidelines in the Materials list, you'll have the right number of cards for your class size, regardless of players' card purchase decisions. As long as you have followed the guidelines in the Materials list everything should work out nicely, allowing for many "teachable moments."
2. Before your students arrive to class, lay out the coal-fired power plant ownership cards (one for each student) in a place where students can gather around them, to look them over. In another location that is also accessible to the students from all sides, neatly lay out the fuel cards. In a third location accessible to the students from all sides, lay out the technology upgrade cards, the natural gas cards and the crushed limestone cards.
3. The students will enjoy playing this game and will want to play it again, so that they can try a different strategy on the second round. If possible, let them play before the unit test, the mid-term exam or the AP Exam, as a review of topics from this unit and topics that will be covered in the Biodiversity, Politics and Economics Unit.

To start the game:

1. Give each player $20,000,000 to start the game. You (the teacher) will act as banker for the game. Realize that you will also play the role of the government, the general public, non-governmental organizations, advertising firms, local school boards and other factions.
2. Explain to the players that they will each be the owner of a coal-fired power plant.
3. Ask the players to gather around the power plant ownership cards and read them. Invite the players to each buy a coal-fired power plant.
4. Give each player a "Sulfur Emissions Permit Exchange Program" record sheet. Ask the students to record the amount of money they have at the beginning of this first round of play, in the first column of their "Financial Status Chart" under the year 2008, next to the "Starting Cash" row.
5. Ask them to look at the technology rating on their power plant ownership card and use the "Plant Emissions Rating Chart" (located about halfway down the record sheet) to determine how many pounds of sulfur are emitted by their plant for every million BTUs. Ask them to write this number in the first column of their "Emissions Status Chart."
6. Tell the players they will need to buy coal for their power plant for the year. Invite them to go to the table where the fuel cards have been laid out and allow each to buy fuel for their power plant for the first year of operation. The availability of the three types of fuel is limited, so that not every person can buy the type of fuel they want each year. (This is why the Materials list calls for a card total that allows only one per person and dictates that there be fuel cards of various types, not just one.) If the players complain that they did not get to buy the type of fuel they wanted, use the "teachable moment" to remind them that, in real life, supplies run out. In this case, they may have to purchase lower or higher grade fuels instead of their first choice fuel, to keep the plant operational.
7. Ask the players to look at the number of pounds of sulfur that are emitted from the fuel they purchased. Ask the players to record this number in the first column of the "Emissions Status Chart" across from the label, "Fuel Rating."
8. During the first round, the natural gas, technology upgrade and crushed limestone cards will not be used, so these boxes on the chart can be ignored for now.
9. Tell the players the passage of the Clean Air Act required the Environmental Protection Agency to set the maximum allowable emissions for six principle pollutants. Sulfur is one of the six air pollutants that is strictly regulated. Tell the players that in order to control the amount of sulfur in the air, a state will issue a limited number of sulfur permits that allow a plant to pollute only up to a certain level. Inform the players that in their region of the state, the government currently gives each power plant five permits. Tell them that each permit covers up to 0.3 pounds of sulfur emissions. Explain that every power plant operator will need to have enough permits each year to cover all their sulfur emissions in order to get paid for that year of running their plant. They can assume a plant will be

shut down if they are not in compliance. (When your students become comfortable with this game, you may want to add interesting twists: for example, you could allow a non-compliant plant to remain in operation with financial penalties, or with closure at a random time, or whatever you think would be typical of a government-enforced system of checks and balances.)

10. Show the players how to tabulate the amount of sulfur their plant emits based on numbers they have written in the first column of the "Emissions Status Chart."
11. After each player has calculated their sulfur emissions for the year, they will need to acquire the appropriate number of permits to cover (or exceed) their emissions output. Players may use the permits given to them by the government, buy extras from other plant owners to cover emissions that go beyond what they have permits for, or they may trade or sell any extra permits they have to other power plant owners. The sulfur permits are on a free-market system once they have been distributed by the government. The government does not offer additional permits, because restricting the number of permits available is the government's method for controlling the overall air pollution in a region.
12. When players' buying, selling and trading of permits is completed, you (the teacher) may act as the government and go around to each player, collecting the permits needed to cover sulfur emissions for each plant. The number of permits needed will vary for each plant and the total coverage the permits offer must meet or exceed the plant's total emissions.
13. You (the teacher) may then act as the general public and go around to the players again, this time paying each power plant owner $12,000,000 for the electricity produced that year.
14. Payment signifies the end of a round. To begin the next round, ask the players to write the year at the top of the next column on the "Financial Status Chart" and the "Emissions Status Chart," then begin the second round as described below.

For the second year and every year after:

1. Ask the students to record their total cash on hand at the beginning of this round (and each successive round).
2. Each player should be given four sulfur permits for this round, instead of five. Discuss why the government would reduce the number of permits issued to each plant for a particular region (introduce the terms "non-attainment region" and "criteria air pollutants" as you talk about the reduction of permits).
3. Allow each player to buy fuel for the year—beware, this can be chaotic. You may or may not want to add order to the process.
4. Explain that there have been advancements in the technology used to reduce sulfur emissions, through the use of crushed limestone and natural gas fluidization. Allow the students to buy these additive cards for

$1,000,000 and $1,500,000 each, respectively, until supplies run out (keep a limit on the number of cards available each year, making adjustments if necessary). Any player can buy as many additive cards as they want, each year, as long as supplies last. **These cards are good for one year only** since additives are used up in the production process.

5. Ask the players to record the reductions on their "Emissions Status Chart" on the "Limestone" or "Nat. gas" rows.
6. Inform the players that they can now buy permanent technology upgrades, as well. Upgrades, such as a wet scrubber building or an electrostatic precipitator, can be had for a price of $2,000,000 per card (keep a limit on the number of cards available, making adjustments if necessary). Any player can buy as many of these cards as they want, each year, as long as supplies last. **These cards are good for as long as the game is being played** since permanent upgrades allow continual reduction in sulfur. Each technology upgrade card that a player buys is kept at their desk and is used over and over each year.
7. Ask the players to record the reductions to their "Emissions Status Chart" on the "Tech card" row.
8. Repeat steps 12-14 from the instructions for the first round.

Fun twists you can add to the game, once it is flowing:

1. Have a non-governmental organization (NGO) come around and buy up extra permits at a competitive price to reduce the total amount of pollution caused by the plants.
2. Have a non-governmental organization (NGO) come around and buy up extra permits at a non-competitive price. In this case, the power companies would sell their permits at a reduced price to advertise themselves as a more environmentally friendly company. In future rounds, the plant owners should be paid 1-2 million dollars extra each year, to compensate for the additional customers they have won over with their "green" actions. Do not announce upfront that this will be the outcome for going green, since a company makes this gamble without knowing whether it'll pay off.
3. When technology cards are limited or sold out, there will be pleas for more to be added to the game. Ask the players to voluntarily put money toward the research and development of new technology (they should not be told upfront how their investment will pay off). After a year or two, add a few more technology cards that are available to everyone—not just the companies that funded the research—for recent advances in technology.
4. Identify a particularly dirty power plant and tell the owner that the local school board and PTA are protesting against the dirty smokestacks due to rising asthma rates in the area. Tell the plant owner that if sulfur emissions are not reduced, they will lose some of their customer base—and will therefore be paid less at the end of the round.
5. Identify another dirty power plant and tell the owner that a renewable energy company has set up a wind power plant in the area and is starting

to take away customers. Ask them how they plan to save their plant. They have many ways to proceed—they may decide to use a cleaner grade of coal, make technological improvements, pay for advertising that compares the pros of their plant to the cons of wind generation, etc.

6. As the students begin to master the basics of the game, incorporate other ideas that make the concepts more realistic and complex. Allow the students to see how politics, economics and the energy industry are intimately connected.

HW: Ask the students to write a response to FR question #2 from the 2004 APES Exam and FR question #1 from the 2000 APES Exam.

HW: Remind the students to prepare for a Ch. 4 *When Smoke Ran Like Water* reading quiz.

Sulfur Emissions Permit Exchange Program

You will receive a certain number of permits from the U.S. government that allow you to “pay” for the sulfur emissions that are put into the air by your coal plant. You may buy additional permits to pay for additional emissions. You may save or sell your permits if you have extras.

Financial Status Chart

Year:	Ex: 2008							
Permits:								
Starting Cash:								

Use the chart below to add up your total sulfur emissions for each year and to keep track of your earnings.

Emissions Status Chart

Year:	Ex: ’08							
Fuel rating:								
Tech cards:								
Natural gas:								
Limestone:								
Plant rating:								
Total sulfur emissions:								

Things to Know:

Plant Emissions Rating Chart

Technology rating at time of purchase	Additional pounds of sulfur per 1 million BTUs at this technology rating
1	0.0 lbs. sulfur/1 million BTUs
2	0.5 lbs. sulfur/1 million BTUs
3	1.0 lbs. sulfur/1 million BTUs

One government permit “pays” for 0.3 lbs. of sulfur per million BTUs per year.

Technology upgrades cost $2,000,000 each and offer continuous reductions.

Additive cards of limestone and natural gas are good for one year only.

Natural gas cards cost $1,000,000 each and take off 0.5 lbs. of sulfur/yr.

Limestone cards cost $1,500,000 each and take off 0.7 lbs. of sulfur/yr.

Yearly pay for one year of plant operation is $12,000,000.

Coal-fired Power Plant Ownership Cards

This coal-fired power plant costs:

$5,000,000

The technology rating for this power plant is: 3

This coal-fired power plant costs:

$5,000,000

The technology rating for this power plant is: 3

This coal-fired power plant costs:

$5,000,000

The technology rating for this power plant is: 3

This coal-fired power plant costs:

$7,000,000

The technology rating for this power plant is: 2

This coal-fired power plant costs:

$7,000,000

The technology rating for this power plant is: 2

This coal-fired power plant costs:

$7,000,000

The technology rating for this power plant is: 2

This coal-fired power plant costs:

$7,000,000

The technology rating for this power plant is: 2

This coal-fired power plant costs:

$9,000,000

The technology rating for this power plant is: 1

This coal-fired power plant costs:

$9,000,000

The technology rating for this power plant is: 1

This coal-fired power plant costs:

$9,000,000

The technology rating for this power plant is: 1

Sulfur Emissions Permits

sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit
sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit
sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit
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sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit
sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit	sulfur permit

Coal Fuel Cards

Lignite Coal **3.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$5,000,000**	**Lignite Coal** **3.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$5,000,000**
Lignite Coal **3.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$5,000,000**	**Lignite Coal** **3.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$5,000,000**
Bituminous Coal **2.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$7,000,000**	**Bituminous Coal** **2.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$7,000,000**
Bituminous Coal **2.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$7,000,000**	**Anthracite Coal** **1.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$10,000,000**
Anthracite Coal **1.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$10,000,000**	**Anthracite Coal** **1.0 lbs. of sulfur/million BTUs** **One year's supply costs:** **$10,000,000**

Technology Upgrade Cards

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

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$2,000,000 per card

0.2 lbs. sulfur reduction

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this is a permanent reduction.

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$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Technology Upgrade Card
$2,000,000 per card

0.2 lbs. sulfur reduction

Keep this card -
this is a permanent reduction.

Limestone Cards

Crushed Limestone Additive Card
$1,500,000 per card

0.7 lbs. sulfur reduction

Card good for only one year - limestone is used in the process.

Crushed Limestone Additive Card
$1,500,000 per card

0.7 lbs. sulfur reduction

Card good for only one year - limestone is used in the process.

Crushed Limestone Additive Card
$1,500,000 per card

0.7 lbs. sulfur reduction

Card good for only one year - limestone is used in the process.

Crushed Limestone Additive Card
$1,500,000 per card

0.7 lbs. sulfur reduction

Card good for only one year - limestone is used in the process.

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$1,500,000 per card

0.7 lbs. sulfur reduction

Card good for only one year - limestone is used in the process.

Crushed Limestone Additive Card
$1,500,000 per card

0.7 lbs. sulfur reduction

Card good for only one year - limestone is used in the process.

Crushed Limestone Additive Card
$1,500,000 per card

0.7 lbs. sulfur reduction

Card good for only one year - limestone is used in the process.

Natural Gas Fluidization Cards

Natural Gas Additive Card
$1,000,000 per card

0.5 lbs. sulfur reduction

Card good for only one year - natural gas is used in the process.

Natural Gas Additive Card
$1,000,000 per card

0.5 lbs. sulfur reduction

Card good for only one year - natural gas is used in the process.

Natural Gas Additive Card
$1,000,000 per card

0.5 lbs. sulfur reduction

Card good for only one year - natural gas is used in the process.

Natural Gas Additive Card
$1,000,000 per card

0.5 lbs. sulfur reduction

Card good for only one year - natural gas is used in the process.

Natural Gas Additive Card
$1,000,000 per card

0.5 lbs. sulfur reduction

Card good for only one year - natural gas is used in the process.

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0.5 lbs. sulfur reduction

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$1,000,000 per card

0.5 lbs. sulfur reduction

Card good for only one year - natural gas is used in the process.

Natural Gas Additive Card
$1,000,000 per card

0.5 lbs. sulfur reduction

Card good for only one year - natural gas is used in the process.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 9

I. Topic: Energy Calculations

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Take a reading quiz for Ch. 4 of the Davis book. When you are finished, turn the quiz over on your desk and answer the following question:

If a faucet is dripping at a rate of one drop every two seconds, and each drop consists of 0.05ml of water, how many liters of water will be lost from this leak in one year? *(788.4 liters of water will be lost per year.)*

III. Activity One: *When Smoke Ran Like Water* - Ch. 4 Quiz 15 minutes

Objectives:

a) TLW demonstrate what they have retained from the Davis book.
b) TLW express and generate interest in the book they are reading.
c) TLW make connections between the examples given in the Davis book and what they are learning in their textbook and class.

Materials:

For each student: one copy of the quiz.

Procedure:

1. Allow the students 5-6 minutes to complete the reading quiz.
2. Ask the students to each trade papers with someone who has another color of pen.
3. Go over each question allowing the students to provide answers and discuss the book in order to build interest in it and to make connections to topics covered in the textbook and in class.

IV. Activity Two: FR Energy Calculation Questions 30 minutes

Objectives:

a) TLW practice formulating energy calculation problems.

b) TLW look for similarities in performing these types of calculations.

Materials:

For each student: their completed Free Response essays from last night's homework, and a copy of the grading rubric for FR question #1 from the 2000 APES Exam, and the grading rubric for FR question #2 from the 2004 APES Exam (or, for the class, put the rubrics on an overhead projector). For the class: a copy of Free Response question #3 from the APES 2005 Exam (to be assigned as homework, below).

Procedure:

1. Begin by discussing the warm-up.
2. Last night's homework included each of the FR questions in the above Materials list. However, calculation-based questions can be very tricky for most students. Today's activity will review the students' attempt to solve these types of questions. Begin by reassuring the students that the essay questions on the AP Exam will give them all the information they need to solve the problem, but they must be ready to handle simple ratios and metric conversions on their own, without a calculator.
3. If your students are practicing conversions, the U.S. Department of Energy website is useful for enabling students to check their work: http://www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html
4. Go over Free Response essay #1 from 2000 APES Exam, working through this problem with the class.
5. Show the students the grading rubric (on an overhead projector or give them each a copy). Go over the points earned for this response. It will be helpful for the students to see that no points are given if the units are not in the answer or if the student's work is not shown for the calculations.
6. Ask the students to work on Free Response essay #2 from 2004 APES Exam on their own. Once they have done as much as they can do alone, ask them to pair up and go further or go over the answers they have.
7. Show the students the grading rubric (on an overhead projector or give them each a copy). Go over the points earned for this response.
8. There will be more Free Response questions using calculations throughout the year. There is a calculation question or a data analysis question on the APES Exam every year. Encourage your students to use ratios and make conversions whenever possible so they can practice these skills before the exam.

HW: Ask the students to write a response to FR question #3 from the 2005 APES Exam.

When Smoke Ran Like Water by Devra Davis
Ch. 4 - "How the Game is Played"

1. What was President Nixon's personal view regarding the environment? How did it compare to his political maneuvering in environmental policy?

2. Name three significant political steps taken for the environment in the early '70s that would have great impacts later.
   a.
   b.
   c.

3. Under the EPA's second head administrator, Bob Fri, what were the first two major topics addressed?

4. The EPA made huge advances in cleaning up the environment—what exactly was its role in this campaign? (Be specific about what the EPA did or was expected to do.)

5. What exactly was the responsibility of the states in the clean-up of air pollution?

6. Who was the most up-in-arms about the tighter air pollution regulations? How did this group fight back?

7. For 50 years, data had been collected on the effects lead has on the brains of children, yet leaded gasoline was still being sold. How was this issue resolved?

8. What was the original objective of Lave and Seskin's research?

9. What two things did Lave and Seskin's research work correlate?

When Smoke Ran Like Water by Devra Davis
Ch. 4 - "How the Game is Played"

Teacher's Version

1. What was President Nixon's personal view regarding the environment? How did it compare to his political maneuvering in environmental policy? *Nixon was not personally sold on concern for the environment and he was weary of environmentalists, but made many policies in favor of the environment since it was a popular stance at the time.*

2. Name three significant political environmental steps taken in the early '70s that would have great impacts later. (Following are six possible answers:) *The Clean Air Act of 1970; the formation of the EPA in 1970 with a 1.4 million dollar budget; the establishment of Earth Day in 1970; National Air Quality Standards were adopted for 5 major pollutants in 1970; Air Quality Control Regions were charted; National Emissions Standards for Hazardous Air Pollutants were adopted.*

3. Under the EPA's second head administrator, Bob Fri, what were the first two major topics addressed? *Lead in gasoline and car emissions.*

4. The EPA made huge advances in cleaning up the environment—what exactly was its role in this campaign? Be specific about what the EPA did or was expected to do. *The EPA set federal air quality standards with maximum daily and maximum yearly averages of pollutants, it set fuel efficiency standards and decided the maximum allowable pollutants emitted from the tailpipe of a car.*

5. What exactly was the responsibility of the states in the clean-up of air pollution? *Each state was responsible for making sure it met the standard outlined by the EPA by instituting car pool lanes, mass transit, state inspections, catalytic converters and other measures to reduce air pollution.*

6. Who was the most up-in-arms about the tighter air pollution regulations? How did this group fight back? *The automobile industry and the oil and gas industries claimed that the standards set could not be met and that meeting them would put them out of business. They protested to Congress and the EPA.*

7. For 50 years, data had been collected on the effects lead has on the brains of children, yet leaded gasoline was still being sold. How was this issue resolved? *It went before a three-judge panel, and one of the judges, J. Skelley Wright, rejected the statement that there wasn't enough evidence to say that leaded gasoline caused brain damage in children. He felt the panel must take the precautionary approach and ban lead (although lead was not completely phased out until 1995!).*

8. What was the original objective of Lave and Seskin's research? *They were economists who were researching whether or not the air pollution created from a booming industrial economy cost more money than was being produced.*

9. What two things did Lave and Seskin's research work correlate? *Air pollution with death rates.*

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 10 - Extended Lab Period

I. Topic: Fossil Fuel Generated Electricity

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Get ready to go on a field trip to a coal-fired power plant. Bring a pen, a notebook (or paper and something firm to write on) and your completed homework from last night (your response to FR essay question #3 from the 2005 APES exam).

III. Activity One: Grade FR Essay on the Bus 15 minutes

Objectives:

a) TLW grade a FR essay to see how the details and facts included in the essay compare to those in the grading rubric.
b) TLW see how their peers' work compares to their own and to the grading rubric.

Materials:

Each student will need their completed essay for FR question #3 from the 2005 APES exam; a pen of another color; and one copy of the grading rubric for this essay, which can be obtained from the www.apcentral.collegeboard.com website.

Procedure:

1. When the students board the bus, ask them to turn in their Free Response essays. Redistribute the essays, making sure no one is grading their own.
2. Ask the students to go over the grading rubric before they begin grading.
3. While grading, the students are to write points earned in the left-hand margin of the paper and underline the word, phrase or sentence that earned the points.
4. When they have finished, ask the students to add up the points earned, write the final grade at the top of the paper and their name at the bottom, and turn the essay in for recording.

IV. Activity Two: Coal-fired Power Plant Tour 60-180 minutes

Objectives:

a) TLW observe an actual coal-fired power plant in operation.
b) TLW develop an idea of how much fuel is used and how much waste heat and particulate matter is produced in the production of electricity.
c) TLW ask questions about this process to scientists who are trained in this particular field.
d) TLW be introduced to career opportunities in science.

Materials:

For each student: one copy of the "Coal-fired Power Plant Field Trip Questions" handout.

Procedure:

1. Prior to class, identify a power plant that serves your area. Call and ask the plant if you can schedule an educational tour. Be sure to tell them your students' level of understanding, so that the tour can be geared to the appropriate level.
2. Distribute the "Coal-fired Power Plant Field Trip Questions" handout. Ask the students to read the handout before arriving at the plant, so that they know what to listen and watch for when they are on the tour. They must complete the handout while on the tour and will turn it in for grading before returning to school.

HW: Ask the students to prepare for the non-renewable energy debate that will take place in the next class period.

Coal-fired Power Plant Field Trip Questions

Learn the answers to these questions during the presentation and tour. Please listen to the information the educator is sharing before asking questions.

1. Draw a diagram of the power plant on a blank sheet of paper. Below the diagram, describe the process by which electricity is generated.
2. When is electricity generated and why is it not generated at a constant rate, day and night?
3. What are the peak hours of operation in the summer? _______________. In the winter? __________________.
4. Which types of fuel are used in this power plant? Which grade of coal?
5. How much fuel is used per day in the summer? ________________. In the winter? _________________. How many train cars is this?
6. How many BTUs or megawatts are produced each day by this plant during the summer? _______________. During the winter? _______________.
7. How hot is the water in the pressurized pipes when it turns the 1st and 2nd turbines?
8. If there is a man-made lake, how is the water from the man-made lake used in the production of electricity?
9. How is the lake ecosystem affected by the power plant?
10. Describe the turbine and explain how it works:
11. What is opacity and how is it measured?
12. What types of pollution are produced in the process of making electricity?

a. How much CO_2 is generated by this plant in the summer? ________________. In the winter? _________________.
b. How much SO_2 is generated by this plant in the summer? ________________. In the winter? _________________.
c. How much NOx is generated by this plant in the summer? ________________. In the winter? _________________.
d. How much fly ash (soot/ash) is generated by this plant in the summer? ________________. In the winter? _________________.
e. How much mercury is generated by this plant?

13. How are these pollutants removed?
    a. Describe how an electrostatic precipitator works:

    b. Describe how a wet scrubber works:

14. How do the emissions from this plant compare to the regulations imposed by the Clean Air Act?

15. From where do the sulfur oxides come?

16. From where do the nitrogen oxides come, if nitrogen is not found in coal?

17. Where does the fly ash go when it is collected?

18. What products does the power plant make besides electricity?

19. If this power plant were to go off-line temporarily what would happen—where would the local area get its power?

20. In what specific ways can residents of this area reduce the need for an additional power plant?

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 11

I. Topic: Non-renewable Energy

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Meet with your debate team and decide the order in which you will present your main points.

III. Activity One: Non-renewable Energy Debate 45 minutes

Objectives:

a) TLW research the pros and cons of each type of non-renewable fuel used to generate electricity.
b) TLW be able to articulate what they have learned and debate against or in favor of various non-renewable fuels.

Materials:

Each student will need the notes they made in preparation for today's debate. For the class: a copy of Free Response question #3 from the 2004 APES Exam (which can be obtained from the www.apcentral.collegeboard.com website), to be assigned as homework, below.

Procedure:

1. Ask the students to divide into their teams and prepare to begin.
2. Allow one team at a time to present a primary point, with each team taking 60 seconds or less. (A primary point would be one that attempts to convince people of the merits of using one type of fuel over another type of non-renewable fuel source. For example, "Nuclear energy is an excellent choice for electricity generation because it does not add sulfur oxides or nitrogen oxides to the atmosphere.") After the first team has made a primary point, allow the other three teams to offer a rebuttal to any information presented, with each team taking no more than 30 seconds. Do not allow the teams to introduce a new primary point during the rebuttal period.
3. After the rebuttal of the first team's primary point, allow a new team to present its primary point. Then repeat the rebuttal process.

4. Continue in this way until the teams are beginning to repeat their ideas, or until there are only 10 minutes left in the class period.
5. Ten minutes before the class period is up, stop the debate. Allow the teams three minutes to confer on a closing argument.
6. Allow each team to present a closing argument.
7. Ask the students to each take out a blank sheet of paper and evaluate the teams' preparedness by answering the following questions:
    a. Write down the name of the team that was the best prepared and delivered the most persuasive argument in today's debate. Which team was the second most prepared and gave the second best argument? Which team was third? Which team was the least prepared?
    b. Based on what you now know about these four non-renewable fuels, rank them from best to worst.
    c. Write down the name of the most well-prepared person on each debate team and the name of the second best-prepared person on each team.
8. Ask the students to turn in their debate evaluations and tell them which team you thought gave the strongest, most persuasive argument.

HW: Ask the students to write a response to FR question #3 from the 2004 APES Exam.

HW: Remind your students to check the year calendar for reading and video assignments.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 12

I. Topic: Renewable Energy

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Oil is used to meet 2/3 of worldwide transportation needs as well as various other industries' needs and the production of electricity. How long can people continue to use oil to meet their demands for energy? *(The U.S. Energy Information Administration projects that world oil use will increase from our current rate of 84.9 million barrels per day (mbbl/day) to 98.3 mbbl/day in 2015 and 118 mbbl/d in 2030. Colin Campbell, from the Association for the Study of Peak Oil and Gas, predicts the world will maximize its use of oil in 2010. Kenneth Dreffeys, a geologist from Shell Oil Co. who worked with Marion King Hubbert on the "Hubbert curve" or "peak oil theory," believes that maximum worldwide use already occurred in 2005 with 84.9 mbbl/day.)*

III. Activity One: Peak Oil Calculations 30 minutes

<u>Objectives:</u>

a) TLW consider the limitations of oil as a primary source of energy for the future.
b) TLW become familiar with the constraints associated with identification and extraction of existing oil reserves.

<u>Materials:</u>

For the class: one black permanent marker; and one empty one-gallon water jug. For each lab group: one 5-gallon bucket; 30 pennies; 10 nickels; 4 quarters; and 5 gallons of ice to fill the bucket. For each student: one copy of the "Recovering Estimated Oil Reserves" handout.

<u>Procedure:</u>

1. Prior to class, prepare one 5-gallon bucket as described for each lab group: Add 1-gallon graduation lines to the inside of each 5-gallon bucket by filling the bucket with one gallon of water and marking the level of the

water with a circle on the inside of the bucket at the fill line. Repeat the process until there are graduation lines from 1 gallon to 4 gallons. Label the graduation lines with numbers from the top down, such that the top of the open container (representing 0km) represents the surface of the earth, and the first graduation mark represents a depth of 1km below the surface, the second is at 2km, etc. and the bottom of the container is 5km below the earth's surface. The students will use these marks to make estimates of where oil reserves lie and the cost of extraction. Cluster 10 pennies—each lying flat—at the bottom of each bucket, and add one gallon of ice up to the 4km graduation mark. Cluster 10 nickels—each lying as flat as you can get them—on top of the ice and cover them with ice up to the 3km graduation mark. Place four quarters flat on the ice, then cover it with ice up to the 2km mark. Cluster 10 pennies—each lying as flat as you can get them—on the ice, then add another layer of ice up to the 1km graduation mark. Lastly, cluster 10 pennies—each lying as flat as you can get them—on the ice and cover with a thin layer of ice, not quite filling the container (otherwise you will have problems with the container overflowing during the activity).

2. When the students arrive, discuss the warm-up briefly. Use the answer to the warm-up to introduce the topic of peak oil and why this source of energy is not inexhaustible.
3. Ask the students to divide into their lab groups. Tell the lab groups that they are each an oil company whose goal is to identify and extract oil from underground reserves. Show them one of the prepared ice buckets. Explain to them that the graduation marks represent the distance underground in kilometers. Inform them of the oil reserves that are found under the ground. Tell them that the pennies represent oil, the nickels represent tar sands (a thicker, high-sulfur oil) and the quarters represent oil shale (a sedimentary rock that is infused with oil that contains sulfur and metal impurities that are expensive to remove).
4. Tell the oil companies that the first thing they must do is read the estimated number of units and the value of each unit (this information is given to them on their handout at step 3) in their territory, in order to calculate the estimated recovery cost of each reserve.
5. After they've calculated the estimated cost of extraction for each reserve, they can begin making any extractions they wish to make.
6. After all extractions are made, the students will answer the reflection questions on the handout and turn it in when they are finished.
7. Distribute the "Recovering Estimated Oil Reserves" handout to each student, give each lab group a bucket and allow the students to begin.

IV. Activity Two: Introduction to Renewable Energy — 15 minutes

<u>Objectives:</u>

a) TLW discover some of the problems with the most common forms of energy capture and transfer.
b) TLW be introduced to the types of renewable energy that are currently being developed.
c) TLW research a particular type of renewable energy product and promote its benefits in a TV commercial or magazine advertisement.

Materials:

For each student: one copy of the "Renewable Energy Product Advertisement" handout. For the class: a diagram of a fossil fuel-fired electric power plant; and a copy of Free Response question #4 from the 2005 APES Exam (which can be obtained from www.apcentral.collegeboard.com), to be assigned as homework, below.

Procedure:

1. Briefly discuss the losses of energy that are common with an internal combustion engine, a typical electricity-producing fossil fuel-fired power plant and an electric motor. Inform the students that while scientists are looking at renewable forms of energy, they can also begin to address some of the losses that reduce the efficiency of our most common methods of capturing and transferring energy.
2. Introduce the concept of a more direct approach to energy capture and use, such as passive solar energy.
3. Ask the students to help you make a list on the board of renewable energy sources (passive solar, active solar, wind, hydrogen, hydroelectric, geothermal, tidal, biomass/biofuel).
4. Tell the students that they will each research one type of renewable energy product and create an advertisement that promotes its benefits. Distribute the "Renewable Energy Product Advertisement" handout and make sure the students understand what is required.
5. Allow the students to choose one product from the list on the handout that they wish to research for their advertisement.

HW: Ask the students to begin working on their "Renewable Energy Project Advertisement" project.

HW: Ask the students to write an essay for Free Response question #4 from the 2005 APES Exam.

Recovering Estimated Oil Reserves

Objectives:

- To consider the limitations of oil as a primary source of energy for the future.
- To become familiar with the constraints associated with identification and extraction of existing oil reserves.

Procedure:

1. Name your oil company: ___________________________________
2. The bucket represents the land territory that your oil company will be using for oil extractions. Preliminary exploration of this region has yielded the estimated number of units given in the chart below.
3. Fill in the "Value of units in cents" column in the chart below—oil is represented by pennies, tar sands are represented by nickels and oil shale is represented by quarters. The value of the unit is equal to the worth of the coin (for example, one unit of tar sands equals 5 cents), which represents the cost of refining the oil into a usable product.

Type of deposit	Estimated # of units	Value of units in cents	Location of the deposit	Estimated cost of recovery	Actual number of units recovered	Actual cost of recovery	Total profit
Oil	10 units	₵	1km				
Oil	10 units	₵	2km				
Oil shale	4 units	₵	3km				
Tar sands	10 units	₵	4km				
Oil	10 units	₵	5km				

4. Before extracting oil, you must first calculate the estimated recovery cost. Use the equation below to estimate the recovery cost, to make sure the reserve is worth the recovery price. Write the estimated recovery cost of each deposit in the fifth column of the chart above.

(Number of units) x (value of a unit) x (depth in km) x ¼ = Estimated Recovery Cost

5. You may now begin any extractions your company wishes to make: Gently reach into the ice and recover as much of the deposit as possible. If some of

the deposit shifts to a lower depth, you may or may not choose to recover all of the deposit.

6. After an extraction is made, record the actual recovery cost in the chart above. Use the equation below to calculate your actual recovery cost. A separate calculation will need to be made for units recovered at different depths.

[(Actual number of units recovered) x (value of a unit) x (actual depth in km) x 1/4] + [(Actual number of units) x (value of a unit) x (actual depth in km) x 1/4] + … = Actual Recovery Cost

For example: If a student recovers 6 pennies that were originally deposited at a depth of 1km, and 4 pennies that shifted to a depth of 2km, their actual recovery cost would be calculated as shown below:

[(6 units x 1 cent x 1km x 1/4)] + [(4 units x 1 cent x 2km x 1/4)] = 3.5 cents

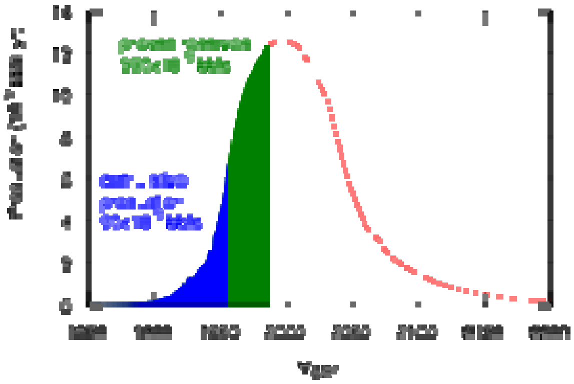
7. Your group can move to the next oil-rich region of your territory to perform another extraction after you have finished the first. Repeat steps 4-6 until your group has made all the extractions you wish to make. Remember, you do not have to recover all the oil in your territory if it is not economically feasible. However, you must make estimated recovery calculations for all 5 deposits in your territory.
8. When you have completed all the extractions you wish to make, tabulate your profit using the equation below, and write it in the last column of the chart above. Profits can be calculated using the equation below:

   (Actual number of units recovered x value of a unit) - actual recovery cost = Profit

9. Complete the reflection questions below and turn this handout in to your teacher.

Reflection Questions:

1. Consider the "Peak Oil Curve," created by Marion King Hubbert in the 1950s. Why does Hubbert, who worked as a geologist for Shell Oil Co., believe that oil production will diminish in the future?



2. What factors kept your company from extracting all the oil that was available in your territory?

3. If there had been a larger number of units in any deposit, how would that have changed the cost? How would it change the profit? Choose a deposit and increase the number of units two or three times, to check your answer.

4. Name three reasons why it is difficult to estimate how much oil exists in the world for extraction.
   a.
   b.
   c.

5. Why is the actual recovery cost often higher than the estimated recovery cost?

6. How does the cost of oil per barrel influence the amount of oil that is recoverable?

7. How will poorer countries be impacted when oil becomes more expensive to extract (because it is harder to get to or takes more money to purify/refine)?

8. How will the wealthier (and more oil-dependent) countries be impacted when oil becomes unaffordable?

9. Describe five ways your life would be affected if oil were no longer available for purchase.
   a.
   b.
   c.
   d.
   e.

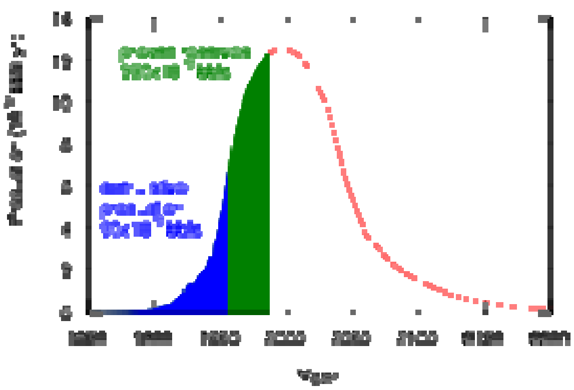
Recovering Estimated Oil Reserves

Teacher's Version

Type of deposit	Estimated # of units	Value of units in cents	Location of the deposit	Estimated cost of recovery	Actual number of units recovered	Actual cost of recovery	Total profit
Oil	*10 units*	*1 ₵*	*1km*	*2.5 ₵*	*If 10 at 1km…*	*If 2.5 then:*	*7.5 ¢*
Oil	*10 units*	*1 ₵*	*2km*	*5 ₵*	*If 10 at 2km…*	*If 5 then:*	*5 ¢*
Tar sands	*1 unit*	*25 ₵*	*3km*	*18.75 ₵*	*If 1 at 3km…*	*If 18.75 then:*	*6.25 ¢*
Oil shale	*10 units*	*5 ₵*	*4km*	*50 ₵*	*If 10 at 4km…*	*If 50 then:*	*0 ¢*
Oil	*10 units*	*1 ₵*	*5km*	*12.5 ₵*	*If 10 at 5km…*	*If 12.5 then:*	*-2.5 ¢*

Reflection Questions:

1. Consider the "Peak Oil Curve," created by Marion King Hubbert in the 1950s. Why does Hubbert, who worked as a geologist for Shell Oil Co., believe that oil production will diminish in the future? *Because he understood that the supply of oil is finite and that as oil becomes increasingly difficult to extract, the amount that is worth recovering will decrease.*



2. What factors kept your company from extracting all the oil that was available in your territory? *The cost of recovery compared to the value of the deposit and the difficulty of the extraction process (the depth, the temperature and our inability to recover all of each deposit).*

3. If there had been a larger number of units in any deposit, how would that have changed the cost? How would it change the profit? Choose a deposit and increase the number of units two or three times, to check your answer. *Larger deposits increase the cost of extraction; profits rise faster than the extraction costs.*

4. Name three reasons why it is difficult to estimate how much oil exists in the world for extraction.
   a. *Exploration is not perfect—exact amounts, depths and quality of reserves are difficult to determine.*
   b. *The price of oil changes, and reserves that are not worth extracting at a lower sales price may be deemed useful deposits at a higher sales price.*
   c. *Not all places are available for oil exploration. Laws are changing to protect some land against exploration, while other areas are opening for development.*

5. Why is the actual recovery cost often higher than the estimated recovery cost? *Oil exploration does not always tell us exact quantity or quality, problems may come up during extraction, reserves may shift or be otherwise lost during extraction, technical problems at the surface with equipment or weather may occur—all of which increase the actual cost of recovery.*

6. How does the cost of oil per barrel influence the amount of oil that is recoverable? *If the sales price per barrel is low, then expensive extractions are not worth recovering. If the sales price per barrel rises, some deposits will be worth extracting. Also, oil that has more impurities, such as oil shale and tar sands, may become affordable to refine if barrel prices are higher.*

7. How will poorer countries be impacted when oil becomes more expensive to extract (because it is harder to get to or takes more money to purify/refine)? *These countries will have less oil and fewer oil products. The price of food will go up, or the people may have to return to human- and animal-labor farming rather than using industrial farming machinery, pesticides and fertilizers. People will have to walk, ride bicycles, use public transportation and engage in business and leisure activities closer to home. There will need to be replacements for plastic and synthetic products, fabrics, etc.*

8. How will the wealthier (and more oil-dependent) countries be impacted when oil becomes unaffordable? *They will be affected in much the same way as poor countries (described above), however it's possible that there will be foresight in either the developed or developing countries to look for alternatives before they are needed. If so, we'll see more time and money*

spent on research and development for replacements in the transportation, agriculture and consumer goods industries, with subsidies and trial work in each area.

9. Describe five ways your life would be affected if oil were no longer available for purchase. *Answers will vary. Following are some possibilities:*
    a. *Less spending and consuming, more reuse and recycling.*
    b. *Replacement of oil-based products with natural fibers.*
    c. *Decrease in food supply, particularly high-quantity inexpensive food.*
    d. *Human-powered modes of transportation or mass transportation used.*
    e. *Less travel; people may do more things closer to home.*

Renewable Energy Product Advertisement

1. Choose a renewable energy product from the list below:

   Biogas digesters
   Compact flourescent lamps
   Gasoline-electric hybrid vehicles
   Ethanol fuel (for vehicle transportation)
   Straight vegetable oil (for vehicle transportation)
   Cellulose insulation
   Super-insulated triple-glazed windows
   Microhydropower systems
   Evaporative cooling systems
   Radiant floor heating systems
   Building-integrated photovoltaic cells
   Saline solar ponds
   Solar chimneys
   Composting toilets
   Residential wind power systems
   Solar hot water heaters—evacuated tube collectors
   On-demand water heaters (or tankless water heaters)
   Geothermal heating and cooling systems

2. Research the strengths and weaknesses of this product and the process it involves, if applicable.
3. Research the product(s) that your renewable energy product would replace. Compare your product to the one(s) it is meant to replace in terms of cost, performance and longevity.
4. Create a TV advertisement using Windows Movie Maker or a magazine advertisement using Microsoft Office Publisher, or use a program similar to these to create either of these types of ads.
5. Your advertisement will be graded on the following features:
   a. How well you sell the product's strengths/benefits.
   b. How captivating or impactful the ad is visually.
   c. The accuracy of the information presented.
   d. Inclusion of a comparison between your product and competing product(s) in cost, performance and longevity.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 13

I. Topic: Alternative Energy Sources

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Gather the necessary supplies and begin the lab assignment.

III. Activity One: Making Biodiesel from Vegetable Oil 45 minutes

Objectives:

a) TLW understand how vegetable oil can be converted into a transportation fuel.
b) TLW practice chemistry techniques used in environmental science.

Materials:

For each lab group: 1 liter of vegetable oil; 3.5g of NaOH (lye); 200ml of methanol; a 2-liter plastic soda bottle (high-density polyethylene of HDPE only) with a tight-sealing cap; a graduated cylinder to measure 250ml of methanol; a mass balance; a 1-pint glass jar with a tight-sealing lid (there can be absolutely no leaks from the lid when the jar is shaken); a funnel; a pair of protective gloves; and use of a fume hood. For each student: a pair of goggles; and a lab apron.

Procedure:

1. Given the dangers of the chemicals that will be used, and depending on the level of skill your students have demonstrated in the handling of chemicals, you may choose to perform this lab as a demonstration.
2. Please educate yourself on the chemicals that will be used in this procedure and take all necessary precautions. Methanol is a poison that can be absorbed through the skin and is fatal if swallowed. It can cause blindness, adverse reproductive and fetal effects, central nervous system depression, digestive tract disruption, and death. Methanol should be handled under a fume hood and students should wear safety goggles, a lab apron and protective gloves. Sodium hydroxide is a corrosive poison that may be fatal if swallowed, harmful if inhaled and can cause burns in

the case of skin contact. It reacts with water, acids and other materials. Please read the MSDS safe-use information on both of these chemicals before you proceed, and use extreme caution in all lab procedures. Everyone present must wear goggles, a lab apron and, if they are handling the materials, protective gloves. This lab should only be conducted with a fume hood and an eye wash station in the room. You are responsible for the safety of your students while conducting this lab procedure.

3. Heat 1 liter of unused vegetable oil to 60°C.
4. While the vegetable oil is heating, perform the following: Under a fume hood, add 200ml of room-temperature methanol to a glass jar. **Caution:** Do not use a cartridge respirator with methanol, and do not use plastic containers to hold methanol—they will react with the methanol and degrade. Methanol absorbs moisture from the atmosphere, so measure quickly and close lids tightly.
5. Add 3.5g of NaOH (lye) to the glass jar and seal the jar tightly with its lid. **Caution:** NaOH absorbs moisture so it is necessary to keep the container airtight as much of the time as possible and measure the NaOH quickly so as not to introduce water to the biodiesel mixture.
6. Swirl the mixture until all of the NaOH is dissolved. The temperature will increase as the chemicals react with one another—this is normal.
7. Swirl or shake the mixture for 10 minutes or more to dissolve all the NaOH. Do not go on to the next step until all of the NaOH has dissolved to yield methoxide. **Caution:** Do not store methoxide in a plastic bottle. Although it is fine to add methoxide to the soda bottle in the next step, over time it will degrade the plastic bottle.
8. Using a funnel, pour the 60°C vegetable oil into a dry 2-liter plastic soda bottle. **Caution:** Do not add methoxide (in the following step) if oil is above 60°C.
9. Under the fume hood, pour the methoxide into the oil, using the same funnel.
10. Remove the funnel, screw the cap onto the soda bottle tightly, until it is completely sealed, and shake vigorously for about ten seconds (or 40 good shakes, five to ten times). The chemicals should not generate appreciable pressure during this mixing.
11. Place the soda bottle on a flat surface and observe as the color of its contents changes from chocolate milk to a rich, darker brown.
12. Over a period of about ten minutes the chemicals will begin to separate, with the lighter-colored biodiesel forming the top layer and the darker-colored glycerin forming the bottom layer. It will take about an hour for most of the glycerin to settle out. (If you choose to spend more time on this project, you can remove nearly all the glycerin by allowing it to settle a full week and giving it a final rinse step. Google home-brewed biodiesel to learn more about purifying this product using a rinse.) The biodiesel will be cloudy after the first hour and will gradually clear the longer it sits.

13. If you'd like to conduct other experiments involving biodiesel, search home-brewed biodiesel sites on the Internet. Consider using the glycerin by-product to make soap (it can be drained from the mixture by melting a hole in the bottom of the soda bottle with a heated metal coat hanger), or washing the biodiesel to yield a purer fuel.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 14

I. Topic: Alternative Energy Sources

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Take the Ch. 5 reading quiz for the Devra Davis book. Turn the quiz over on your desk when you have finished and draw a labeled diagram of a hydroelectric power plant.

III. Activity One: *When Smoke Ran Like Water* - Ch. 5 Quiz 15 minutes

Objectives:

a) TLW demonstrate what they have retained from the Davis book.
b) TLW express and generate interest in the book they are reading.
c) TLW make connections between the examples given in the Davis book and what they are learning in their textbook and class.

Materials:

For each student: one copy of the quiz.

Procedure:

1. Allow the students 5-6 minutes to complete the reading quiz.
2. Ask the students to trade papers with someone who has a different color pen.
3. Go over each question, allowing the students to provide answers and discuss the book, in order to build interest in it and to allow connections to topics covered in the textbook and in class.

IV. Activity Two: Ethanol as a Transportation Fuel Substitute 30 minutes

Objectives:

a) TLW examine the economic and environmental consequences of using ethanol as a car fuel.

Materials:

For each student: a computer with Internet access; and one copy of the "Honk If You're Green" handout. For the class: a copy of Free Response question #1 from the 2002 APES Exam (which can be obtained from www.apcentral.collegeboard.com), to be assigned as homework, below.

Procedure:

1. Distribute the "Honk If You're Green" handout.
2. Ask the students to divide into lab groups. Each group should then divide up the questions on the handout such that each student is researching the group of questions listed for a particular number 1-7.
3. Give the students about 10-15 minutes to research their set of questions.
4. Allow the students about 10 minutes to share their research with their lab group.
5. Begin a discussion by going over the answers to the questions listed. Push the students to cite the sources of their data. Ask them if there are particular areas that they feel need to be further researched by scientists. Ask the students to what degree they think the U.S. should invest in ethanol as a substitute fuel (should we change the pumps? Change cars' fuel systems? Subsidize agriculture? etc.).
6. Ask your students to consider the following quote from David Pimentel, an agricultural scientist at Cornell University: "If all the automobiles in the United States were fueled with 100% ethanol, a total of about 97% of U.S land area would be needed to grow corn feedstock." Ask the students if they think the substitution of gasoline with ethanol is a sustainable solution. Ask them what solutions they propose.

HW: Ask the students to write an essay for Free Response question #1 from the 2002 APES Exam.

HW: Ask the students to continue working on their "Renewable Energy Product Advertisement" project.

When Smoke Ran Like Water by Devra Davis
Ch. 5 - "Zones of Incomprehension"

1. Dr. Needleman studied baby teeth of school children. What did he find in his study?

2. What did Needleman spend "more than ten years and thousands of dollars" fighting?

3. Summarize Davis' experience when she was on the panel to classify chemicals for the National Toxicology Program list of carcinogens.

4. Name the two primary arguments used by manufacturers for NOT classifying a substance as a carcinogen when there was evidence that it was.
   a.

   b.

5. In response to these arguments, Davis points out the goal of public health science is:

6. What are some of the research flaws of dealing with public health data?

7. How do scientists decide what is significant in terms of correlations and possible causes and effects?

8. Explain what the term "junk science" means. Who coined the phrase?

9. Why is it significant that federal agencies must follow the guidelines issued by the Office of Management and Budget (OMB) on quality, integrity and objectivity of information disseminated to the public?

10. What did the 16-year study by the American Cancer Society of 5,000,000 people living in 15 cities conclude?

When Smoke Ran Like Water by Devra Davis
Ch. 5 - "Zones of Incomprehension"

Teacher's Version

1. Dr. Needleman studied baby teeth of school children. What did he find in his study? *The IQ of children correlated with levels of lead in their baby teeth, regardless of any other factor.*
2. What did Needleman spend "more than ten years and thousands of dollars" fighting? *Suits and formal allegations filed against his research findings.*

3. Summarize Davis' experience when she was on the panel to classify chemicals for the National Toxicology Program list of carcinogens. *She saw big companies fight scientific classification of carcinogens successfully, keeping chemicals off the National Toxicology Program list for long periods of time.*

4. Name the two primary arguments used by manufacturers for NOT classifying a substance as a carcinogen when there was evidence that it was. *(Following are three possibilities:)*
    a. *Animals are not the same as humans and so tests on animals should not be considered relevant to human health.*
    b. *More information is needed*
    c. *Case studies in epidemiology have a sample size that is too small.*

5. In response to these arguments, Davis points out the goal of public health science is: *To speculate the harm of a substance and err on the side of caution.*

6. What are some of the research flaws of dealing with public health data? *Large, messy data sets, few controls and too many variables.*

7. How do scientists decide what is significant in terms of correlations and possible causes and effects? *Use of $p<0.05$; a smaller sample size means that it is more likely that a strange coincidence will occur; large sample size means that it is less likely that a strange coincidence will occur.*

8. Explain what the term "junk science" means. Who coined the phrase? *The term was used to discredit research results from scientists when chemical companies wanted to oppose what the scientists had found. It was originally coined by lawyers trying to discredit ideas with which they did not agree.*

9. Why is it significant that federal agencies must follow the guidelines issued by the Office of Management and Budget (OMB) on quality, integrity and objectivity of information disseminated to the public? *It places a money-giving branch of government in charge of deciding what is sound science and puts an economic lens on what is decided by the Environmental Protection Agency (EPA).*

10. What did the 16-year study by the American Cancer Society of 5,000,000 people living in 15 cities conclude? *The risk of dying from breathing polluted air was equal to that of living with a smoker, and there was an 8% increase in the death rate from lung cancer with every 10-microgram increase in (invisible) air pollution.*

Honk If You're Green

Two-thirds of all oil consumed in the United States is used for transportation. One-third of all greenhouse gas emissions in the United States come from transportation. Finding a cleaner way to power cars, buses, trains, trucks, boats and planes would have a profound effect on consumption and pollution. Ethanol has been the key solution proposed for these problems and within a very short time period agriculture, legislation and the economy has made way for a shift in the direction of this corn-based fuel. Is the search over—is ethanol the right solution? Divide up the following questions among your lab group members and use the Internet to research the answers. Keep track of the names of the websites you use for each part of your response. Be sure to use multiple sites, to get complete information, be aware of the source of the information and look for scientific references to facts and statistics. When you finish your research, share the information you have gathered with your lab group.

1. How do the greenhouse gas emissions from ethanol compare to those of gasoline when you factor in the growing or extracting and the processing or refining of each?

2. How will growing crops for ethanol affect U.S. food production and our reliance on imported crops? Are farmers switching over from growing other necessary crops? Will we be eating food that has traveled farther, requiring use of more transportation fuels?

3. Do cars get the same mileage running on ethanol as they do running on gasoline? If not, how are greenhouse gas emission comparisons affected when mileage is factored into the equation?

4. How will the use of corn as a fuel affect the industries that rely on the availability of corn (for example the dairy industry, beef industry, etc.)?

5. Are there subsidies for growing corn that should be considered when calculating the full cost pricing of the product?

6. Is corn a crop that improves or reduces soil quality? Is corn a low-water crop or a water-intensive crop? Does growing corn require a large amount of fertilizers, pesticides or petroleum products for production? How do the environmental impacts of growing corn compare to the environmental impacts of extracting oil?

7. What other carbon sources besides corn can be used to make biofuel? Which source(s) makes the most sense from an environmental standpoint?

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 15 - Extended Lab Period

I. Topic: Hydroelectric Power

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Get ready to go on the hydroelectric power plant field trip. Bring a pen, notebook (or paper and something firm on which to write) and your completed 2002 FR essay #1 from last night's homework.

III. Activity One: Grade a FR Essay on the Bus 10 minutes

Objectives:

a) TLW grade a FR essay to see how the details and facts included in the essay compare to those in the grading rubric.
b) TLW see how their work compares to a peer's and to the grading rubric.

Materials:

Each student will need their completed FR essay for question #1 from the 2002 APES Exam; a pen of another color; and one copy of the grading rubric for this essay (which can be obtained from the www.apcentral.collegeboard.com website).

Procedure:

1. When the students board the bus for the field trip, ask them to pass in their Free Response essays. Redistribute the essays, making sure that no one is grading their own paper.
2. Ask the students to go over the grading rubric before they begin grading.
3. While grading, the students are to write points earned in the left-hand margin and underline the word, phrase or sentence that earned the points.
4. When they have finished, ask the students to add up the points earned, write the final grade at the top of the paper and their name at the bottom and turn the essay in for recording.

IV. Activity Two: Hydroelectric Power Plant Tour 60-180 minutes

Objectives:

a) TLW observe a hydroelectric power plant in operation.
b) TLW be able to ask questions to scientists who are trained for this particular field of work.
c) TLW be introduced to career opportunities in science.

Materials:

For each student: one copy of the "Hydroelectric Power Plant Field Trip Questions" handout.

Procedure:

1. Prior to class, identify a hydroelectric power plant in your region and schedule a class tour. If there is no plant close enough to visit, check to see if there is a wind energy generating station in your area. If not, consider building a model of a hydroelectric power plant with your students. (To do this, you would use a tube of water siphoned off a basin/reservoir, place a fan blade in the stream of the water and hook the mechanism to a generator.) Or, you could look in the phone book for a company that produces micro-hydroelectric systems. Ask the company if a representative could bring a micro-hydroelectric system to your class, to show your students.
2. If you are able to schedule a visit to a hydroelectric power plant, distribute the "Hydroelectric Power Plant Field Trip Questions" handout. Ask the class to read the handout before arriving at the plant, so that they know what to listen and watch for when they are on the tour. They are to answer the handout questions while they are on the tour and turn the handout in before returning to school.

HW: Ask your students to write a response to the following question and be ready to turn it in tomorrow: What are the similarities and differences between hydrogen energy and hydroelectric energy?

HW: Remind your students to check the year calendar for reading and video assignments.

Hydroelectric Power Plant Field Trip Questions

Learn the answers to these questions during the tour. Please listen to the information the educator has to share with the class before asking questions. Questions 11-13 may require you to draw on what you've learned so far in this course.

1. How much power does this plant generate at full capacity?

2. How does this output compare to that of the coal-fired power plant you visited?

3. Is electricity stored at this plant or generated on demand? If it is not stored, describe why not.

4. How has the ecosystem upstream changed with the building of this dam (consider species biodiversity, food web complexity, nutrient availability, water temperature, etc.)?

5. How has the ecosystem downstream changed with the building of this dam (again, consider species biodiversity, food web complexity, nutrient availability, water temperature, etc.)?

6. Describe other impacts (non-environmental) that are associated with this dam.

7. How much did it cost to build this dam?

8. How long is this dam expected to be fully functional?

9. Are there any ways the electricity output could be increased to meet increased energy demands?

10. What pollution is associated with the construction and operation of this dam?

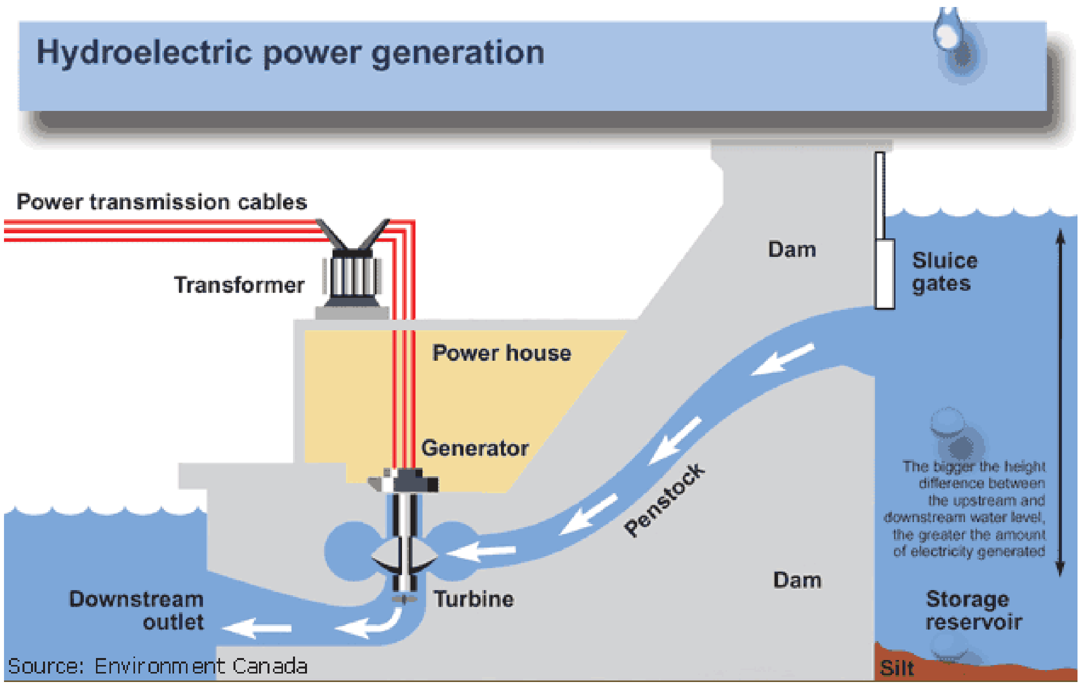
11. Describe five things that you feel are the most important differences between a hydroelectric power plant and a coal-fired power plant:
    a.
    b.
    c.
    d.
    e.

12. Besides generating electricity, what are some other ways the energy of water is harnessed for human use?

13. What is the original source of energy that drives hydroelectric power?

14. In the early part of the century, hydroelectricity provided nearly 50% of electricity in the U.S. Energy demands have increased exponentially, such that the power supplied by hydroelectric dams is down to about 10% today. Dams have already been built in most of the optimal locations for large-scale hydroelectric power generation. With few large rivers left to dam, what is the future for hydroelectric power generation?

15. The diagram below shows the structure of a typical hydroelectric power plant. In the space below this diagram, draw your own diagram of the power plant you visited today. Label each part of the diagram with details of the dam (for instance, what is the distance of the head—the difference between the upstream and downstream water level; how many penstocks are on the dam, etc.)



AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 16

I. Topic: EcoHome Project

II. Warm-up: 5 minutes

Prior to class, write the following on the board: If you could live anywhere in the world, where would you be? If you could live in any type of structure—house, apartment, cabin, barn, teepee, tree house, yurt, Hogan, etc.—what would it be and/or what would it look like?

III. Activity One: Begin EcoHome Project 10 minutes

Objectives:

a) TLW research the abiotic conditions of the location in which they would like to live.
b) TLW begin considering the challenges they would face living in that particular location.

Materials:

For each student: one copy of the "EcoHome Project" handout, the "EcoHome Location Attributes" handout and the "Meeting Your Needs Sustainably" handout.

Procedure:

1. Begin by discussing the warm-up. Tell the students they are going to design and build their environmental dream home. Let them know that they can live anywhere in the world, in any kind of structure, and the only requirement is that the dwelling must be environmentally sustainable. Tell the students that this project will challenge them to incorporate as many of the ideas that they can from all the concepts they have learned so far this year. This culmination project will count as a major test grade.
2. Distribute the handouts and allow the students time to discuss ideas with a classmate.
3. Ask the students to bring in these handouts (and any other EcoHome handouts they receive) each day, so that when concepts are presented in

class, they can jot down items or processes they want to incorporate in their EcoHome.

IV. Activity Two: Share Renewable Energy Product Ads 20 minutes

Objectives:

a) TLW share what they have learned about a particular environmentally sustainable product.
b) TLW be introduced to other products and processes that are meant to replace those that are less sustainable.

Materials:

For the class: a computer, projector and screen on which to display advertisements; and a copy of Free Response question #1 from the 2001 APES exam (which can be obtained from www.apcentral.collegeboard.com), to be assigned as homework, below.

Procedure:

1. Ask the students to email or put on a flash drive their TV commercials or magazine advertisements, so you can play or display them on a screen for the entire class.
2. Ask the students to be ready to write down the names of any products or processes they would like to incorporate into their EcoHome project.
3. Show the students' advertisements.

HW: Ask the students to write an essay for Free Response question #1 from the 2001 APES exam.

EcoHome Project

For this project each student will be required to design and build a dream home that is environmentally sustainable. This means that all electricity, building supplies and wastes must be chosen based on criteria that pertains to environmental responsibility—i.e., which choice requires minimum transportation, minimum processing, minimum resource use, minimum energy use, etc. This project will serve as a test grade for chapters covered in the Resources and Energy Unit and will serve to demonstrate your understanding of all environmental science subjects studied thus far (air, water, soil, ecology, toxicity, etc.).

Project Requirements: **Due date:**

1. "EcoHome Location Attributes" handout
   You must fill in this worksheet completely and accurately to earn full credit.

2. "Meeting Your Needs Sustainably" handout
   You must fill in this worksheet completely and accurately to earn full credit.

3. Floor plan of your EcoHome
   The floor plan of your EcoHome will need to be an original drawing that you create on graph paper using one square of the graph grid to represent one square foot. Your EcoHome must, at the minimum, have a kitchen, a bathroom and a bedroom. Your floor plan must include a bird's eye view of the layout of the rooms (if your house is a two-story building, or has multiple levels, you will need to have a floor plan for each level).

4. Model of your EcoHome
   The model of your EcoHome will need to be built on a piece of foam-core board or other firm surface so it can be transported safely to the classroom for grading. Your model can be made from any materials that logically represent the actual materials that you would use to build a real house.

EcoHome Presentation

You will present your EcoHome project in class, explaining your floor plan(s) and model to your teacher and peers. Be ready to answer the following questions during your presentation:

- Where is your home located? What abiotic factors are important to take into consideration at this home site?
- What type of materials would you use to build your house? Explain why these materials were chosen and how they are sustainable.
- How will you meet your electricity needs sustainably?
- How will you meet your fresh water needs sustainably?
- How will you meet your hot water needs sustainably?
- How will you meet your home heating needs sustainably?
- How will you meet your home cooling needs sustainably?
- How will you prepare food sustainably (obtaining food, storing food, cooking food, disposing of food waste)?
- How will you handle your grey (non-sewage) waste water sustainably?
- How will you handle your sewage water sustainably?
- Explain how you obtained your interior furnishings, how you'll handle transportation to and from your home, or any other features you've included in your EcoHome presentation.

EcoHome Location Attributes

Use the Internet to fill in information below about your home site location.

Location Data:

Continent:	
Country:	
State/region:	
City:	
Latitude and longitude:	
Elevation:	
Topography:	
Connected to public utilities?	

Climate Data:
Following are websites that might help you: www.worldclimate.com**,** www.weatherbase.com, http://www.awea.org/faq/usresource.html, http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/atlas/ and **http://www.eere.energy.gov/.** If these sites do not provide the particular information you're looking for, search the Internet until you find what you need.

	Summer	Fall	Winter	Spring
Average temperature				
Average precipitation				
Average humidity				
Average wind speed				
Average solar radiation				
Length of growing season				

Meeting Your Needs Sustainably

Explain how you intend to handle each of the following issues, using more than one system for each challenge, if desired.

	Traditional method	Traditional demand	How you will meet your needs—first-choice solution	How you will meet your needs—second choice
Electricity	Fossil fuel-fired power plant	10,000 kilowatt-hrs/yr or 25-30 kW-hr/day per household		
Heating	Air blows over coils that contain refrigerated fluid	How many heating days does your location demand?		
Cooling	Air blows over coils that contain refrigerated fluid	How many cooling days does your location demand?		
Insulation	Fiberglass in walls and roof			
Food	Grocery store	2000 kC/day per person		
Light	Incandescent bulbs			
Transportation	Individual cars for each person	12,000 miles per year per car, 1 gallon/day per person		
Clean water	Public water lines from city aquifer, lake, etc.	200 l/day per person (includes hot water)		
Hot water	Electric or gas water heater	100 l/day per person		
Grey water	City pipes to municipal water treatment plant	Combined with sewage total per day		
Sewage water	City pipes to municipal water treatment plant	Grey and sewage = 220 gallons per day		

Trash disposal	Public sanitation pick-up, goes to landfill	2 kg/day per person		
Cooking				
Refrigeration				
Washing and drying clothes				
Building supplies	Hardware store			
Furnishings, consumer items	Department stores			

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 17

I. Topic: Green Architecture

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Make a list of all the ways you use electricity in a typical day. Then write the kilowatt-hour demand beside each item/use on the list. Then write the number of minutes you use each appliance on the list/engage in the electricity-using activity. Using the kilowatt-hour measurement you took a few weeks ago, calculate the average number of kilowatt-hours you use each day.

III. Activity One: Calculate Your Personal Energy Needs 10 minutes

Objectives:

a) TLW review the amount of kilowatt-hours demanded by the particular appliances they use and activities they engage in each day.
b) TLW identify solutions for meeting their energy needs, or find ways to reduce their energy needs.

Materials:

For each student: a list of the kilowatt-hour demands of each appliance they use (they can use the handout from Day 5 of this unit) or activity they engage in; and a calculator.

Procedure:

1. Prior to class, list on the board or on an overhead transparency the kilowatt-hour use rates for all the appliances your class has tested (see the handout from Day 5 of this unit).
2. While your students are completing the warm-up, circulate to help them calculate the most accurate estimate of their individual energy needs. Remind the students to add the items they might not think of using directly or daily such as air heating and cooling, hot water heating, refrigerator, washing machine and dryer, etc. Items that are used weekly, monthly or seasonally will need to be calculated for the month or the year and then assigned a daily average to be added to the student's per day total.

3. After they have completed the warm-up, ask the students how their daily energy demands compare to the national average of 30 kilowatt-hours/day.
4. Discuss the fact that they must plan to meet their own energy demands for their EcoHome project. They may not decide to completely bow out of electricity use; instead, they must find a way to meet at least part of their current electricity demand. Using 10,000 kilowatt-hours/year (or the 30 kilowatt-hours/day) average, your students may choose to reduce some of their electricity use by proposing a feasible reduction plan. Ask the students to each go over their reduction plan with you, and if you approve, they may write their newly calculated energy demand total on their "EcoHome Location Attibutes" handout.

IV. Activity Three: Solutions in Architecture 35 minutes

Objectives:

a) TLW build a small structure using a sustainable building material.
b) TLW compare the interior temperature changes for their housing structure to those of their peers' designs.

Materials:

Each lab group will need a "Green Building Rings" handout (which follows this lesson plan), as well as a different set of building materials, as follows: The Earthbag Group will need: one box of fold-top sandwich bags; a large mixing bowl of dirt (without debris); a couple of large serving spoons or small garden trowels; and 30 twist ties. The Adobe Brick Group will need: 5 lbs. of modeling clay; and one box of floss (to cut the clay into blocks). The Strawbale Group will need: natural shredded wood fibers (looks like Easter basket fluff, but is made of wood fibers; a brand name to look for is "Excelsior"—they make 1.9-liter bags available at Michael's craft stores); 20 twist ties; and 1 lb. of clay. The Cordwood Group will need: one large mixing bowl of landscaping mulch; 2 lbs. of clay; and a couple of large serving spoons or small garden trowels. The Earthship Group will need: one 4-ft. piece of ½-inch polyethylene foam pipe insulation; 1-3 large pairs of sharp scissors; 1 lb. of clay; a large mixing bowl of landscaping mulch; and a couple of large serving spoons or small garden trowels. The Aerated Concrete Group will need: 1 lb. of Crayola® Model Majic. For the class: 7 thermometers (one for taking the interior temperature of each structure, and one for taking the temperature outdoors); enough pieces of foam-core board to allow half a piece for each lab group (or you may use large, heavyweight paper plates); several drinking straws; small metric rulers; a computer, screen and projector; several pictures of each type of sustainable

building structure, to be shown in this order: adobe/clay/cob; cordwood; Earthbag; straw bale; Earthship (tire); and aerated concrete houses. (To find the best pictures, type in the name of each building technique, one at a time, in Google "Images." Or, use the photos from this website: http://www.greenhomebuilding.com/natural_building.htm.)

Procedure:

1. Prior to class, cut each piece of foam-core board in half with an Exacto knife or scissors, so that each lab group has half a piece (you can also use large, heavyweight paper plates for each lab group). Make copies of the minimum and maximum wall diameter handout that follows this lesson plan ("Green Building Rings") and glue one copy onto the center of each half piece of foam-core board (or large, heavyweight paper plate). The students will be asked to build a dome-shaped structure on this piece of foam-core board/paper plate with the materials they are given (from the list above). The space between the two circles on the handout will be the maximum allowable width of the walls for each housing structure. When the students build their models, they must try to fill this space as evenly as possible without going over or under the parameters, so that each model can be compared against the others for temperature retention.
2. Introduce the reasons for using alternative building materials by briefly discussing the problems associated with using wood, concrete and brick. Following are some of the key issues:
    a. Discuss which building materials are renewable and which are not. Discuss the amount of resources and energy that go into producing, processing and transporting the building material used for a project.
    b. Discuss the toxicity of the waste that results from each type of building material. Discuss which building materials are toxic or harmful during processing and building and which are disposable.
    c. Which building materials would a person choose if they wanted to optimize the pros of new construction and minimize the cons, from an environmental standpoint.
    d. Each type of building material has an insulating capability, also referred to as its heat retention index, or R-value (the higher the R-value, the better, because this enables the home to maintain a steady temperature). For example, if you compare the R-values of several common types of insulating materials, each of one-inch thickness, polystyrene foam has an R-value of 7, loose cellulose has an R-value of 3, and straw bales have an R-value of 3. Each of the materials the students will be building with today have different R-values, so part of their experiment will be to test the heat retention of these materials.

3. Show pictures of alternative building materials and techniques and discuss.
    a. Show the class some pictures of adobe/clay/cob and cordwood houses made entirely of materials found on-site—clay, soil, cordwood, straw and sand. The excavation site upon which an adobe house is built can be used to make the house partially subterranean. Adobe is a very old building technique used throughout Africa, south Asia and the North American southwest by Native American tribes. You might want to find pictures of some of the older-style adobe structures from each culture or continent.
    b. Show the class some pictures of earthbag houses made from bags filled with dirt taken from the home's location site. Earthbag houses are inexpensive and easy to build, requiring the work of only one person or a few. The structures can take on any shape, and because the dirt in each bag is mobile, there tends to be excellent airtight seals between bags, and thus no ventilation through the walls. Once built, the house can be given an adobe or clay finish. As with adobe houses, an earthbag house can be partially subterranean if built in the excavation hole from which dirt was removed, giving the house an even greater temperature change resistance.
    c. Show the class pictures of strawbale houses covered with adobe finishes. Explain that these homes' thick walls, which include air spaces, offer a heat retention index of R-54 because there is very little ventilation through the bale.
    d. Show the class some pictures of earthship homes built with used tires that are filled with sand taken from the site. Besides finding a use for a material that is very difficult to dispose of, earthship houses are ideal for climates that are very cold or very hot because they do not allow ventilation through the walls, whose thermal mass is enormous (each tire weighs about 300 pounds after it has been filled with dirt). An earthship house can also be partially subterranean (if built in the excavation hole where the dirt was removed), giving it an even greater temperature change resistance.
4. Tell the class that they will divide into lab groups and build small, dome-shaped models of these sustainable building structures in order to test and compare the heat retention of each. Let them know that, whichever model they are assigned to build, they must make the walls the exact thickness that is drawn on the foam-core board so that an accurate comparison can be made of the different structures' heat retention. Emphasize that they need to build the structure as airtight as possible so it can retain heat competitively.
5. Tell the students that a drinking straw must be placed at the bottom of the structure they plan to build so that a thermometer can be inserted through the wall into the interior of the house. Before the students begin building, they can lay the drinking straw on the foam-core board base so that the

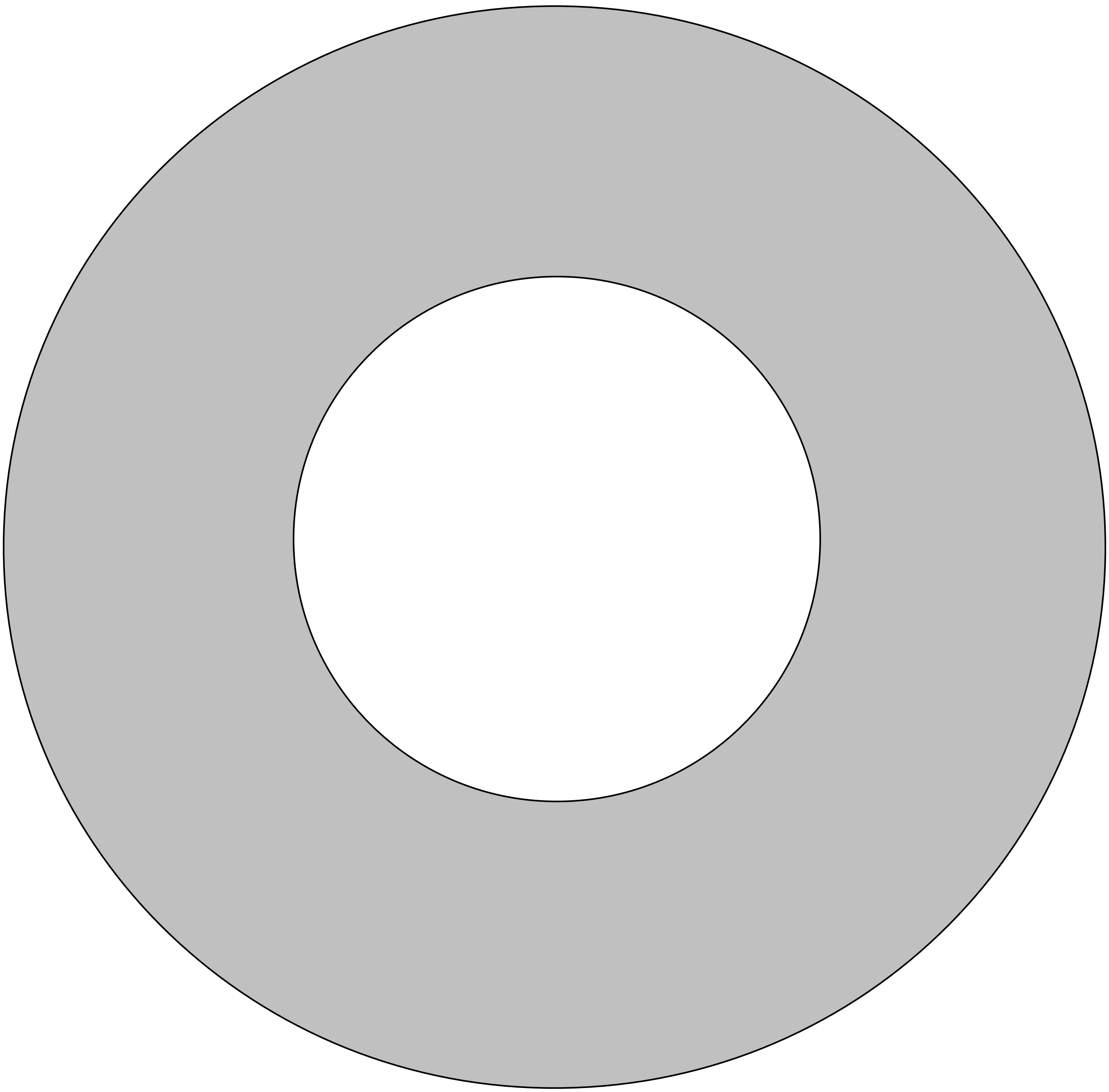
straw transects the two circles. They can then build the structure between the two circles such that the straw is pinned into place and a thermometer can be slipped into the straw to obtain interior temperature readings.

6. Distribute the building supplies, being sure to give each lab group any instructions or tips that pertain specifically to the type of sustainable house they're building.
7. Leave the computer on slide show mode so that it continues to cycle through the photos you have collected, for reference as the groups work. Circulate to assist any groups as they build.
8. As you visit each lab group, ask questions to see if they understand why people are looking for alternatives to wood, brick and concrete building materials:
    a. Are these alternative building materials renewable or non-renewable? *(The straw is the only renewable resource, however clay and sand are very abundant and currently there is a seemingly inexhaustible supply of used tires available.)*
    b. What is the relative cost of the supplies you are using? *(The tires, sand and clay, if taken from the home's building site, are all free. The bags can be obtained by reusing feed sacks, the strawbales cost less than $10 each, and rebar to hold the bales together must be purchased.)*
    c. How far do these building materials need to be transported, to get to the building site? *(The sand and clay would be found at the site, the straw bales and tires would be transported from local sources, and rebar would come from a mined source some distance away.)*
    d. In what type of environment would the type of house you're building perform best? *(In dry, hot climates with extreme temperature changes, such as in the desert; cold climates; windy regions; regions with moderate to average levels of precipitation; and regions with four seasons.)*
    e. In what types of climates would the type of house you're building not perform as well? *(Most of these alternative homes do not fare well in moist or humid environments or in climates where the temperature is constant day and night, year round.)*
9. Allow the structures to dry overnight and test them on the next day in which you have full sun: Record the temperature inside each structure while the structures are still in the classroom. Then allow the structures to sit in the sun with the thermometers in place (one inside each drinking straw). Record the temperature of each structure at regular intervals. Be sure to record the temperature of a thermometer that is simply lying in the sun at the same intervals, for comparison to the structures' interior temperatures. Those structures that have a very slow interior temperature change are building structures with higher R-values.

HW: Ask the students to explore these sustainable building techniques on the Internet and choose the type of house they would like to build for their EcoHome project. They will need to choose a technique that suits their particular location. For example, point out to them that if their chosen location is the rainforest, none of the building techniques covered today would be applicable because of the rainforest's moisture and lack of temperature change.

Green Building Rings

Build your walls to fill the darkened space below. Do not exceed the inner or the outer parameters.



AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 18

I. Topic: Solar Energy

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Using your pointer finger, trace the path that you'd see the sun take across the sky if you watched it from sunrise to sunset. Now depict the path of the sun on paper, using a labeled diagram.

III. Activity One: Solar Energy Principles 20 minutes

Objectives:

a) TLW predict the apparent path of the sun across the sky.
b) TLW track the apparent path of the sun across the sky.
c) TLW recognize the changes that occur in the sun's apparent height with the change in seasons.

Materials:

For each student: one overhead transparency marker; one disposable plastic container in the shape of a bowl; one blank sheet of copy paper; and one compass (if you do not have enough compasses to allow one for each student, perform the compass activity yourself, as outlined in step 2 below). For the class: one compass (if you do not have enough compasses to allow one for each student); one piece of chalk; a stapler; and a meter stick.

Special note: This procedure was written for teachers living in North America. You will need to make the necessary adjustments if you are teaching in another hemisphere.

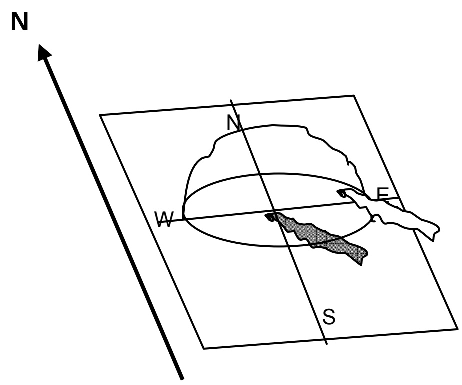
Procedure:

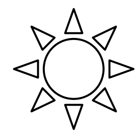
1. Prior to class, make a sun tracker for each student or, if time allows, have the students make their own during class. To make a sun tracker, fold a blank sheet of paper in half each direction. Using a thin-tipped marker, trace both folds so the lines cross at right angles in the center of the page. Staple the plastic bowl onto the piece of paper **so that the bowl is face-down and centered directly over the point where the two lines cross**.

Label the top of the paper North, the bottom of the paper South, the right side of the paper East, and the left side West (see step 7 for a diagram of a sun tracker).

2. Find a place outside, near your classroom, where you are able to see the east and west horizons fairly well. If you do not have enough compasses to allow one for each student, perform the following: Use a compass to find true north and draw a one-meter line alongside the compass on the sidewalk, using a piece of chalk. Place an arrow and the letter "N" at the top of this line to give the students a place to orient their sun trackers. About four students can line their sun trackers up to this line at one time. Repeat this process about a meter away for the next four students to use, until there are enough north lines to accommodate all the students in your class.
3. Give each student a sun tracker and an overhead transparency pen. Ask the students to predict the path of the sun on their sun tracker by drawing a line across the bowl showing the sun's path for the winter and summer solstices and the spring and autumn equinoxes. Ask the students to label each path.
4. Discuss the concept of the equinoxes and the solstices in regard to the relative position of the sun. You may need to review the positions of the earth and sun in this discussion to remind the class how seasons change due to the tilt of the earth (allow the students to perform a simulation of this concept using two balls; seasonal change is an unusually difficult concept for many kids because most formulated their explanations of how the seasons work early in childhood, often based on misinformation from a respected adult). Here are a few questions you can use to discover how well they understand these concepts and where misconceptions lie:
    a. Does the sun ever appear directly overhead where you live? *(If you live north of the Tropic of Cancer, the sun will never appear to be directly overhead at any time of year (only southern Florida, southern Louisiana and southern Texas are south of the Tropic of Cancer). The sun will always appear to travel across the southern part of the sky. However, it will come to its highest point in the sky at the summer solstice.)*
    b. If the sun appeared to travel directly from the east to the west and appeared to be directly overhead at noon on December 21st or 22nd, where would you be? *(Anywhere along the Tropic of Capricorn. For instance, in South Africa, southern Australia or central Chile.)*
    c. Using your pointer finger, trace a path in the sky that indicates the correct direction for the apparent movement of the sun on June 21st if you lived on the equator. *(The sun would appear to rise just north of due east, travel across the northern sky and set just north of due west.)*

5. Ask the students to trade their transparency pens with another student so that they have a second color with which to track the actual path of the sun on their sun tracker.
6. To begin collecting data on the sun's apparent path, the students need to orient their sun trackers so that the N at the top of their tracker is pointing to north. To do this, the students can align the edge of their sun tracker on the ground against one of the north line marks that you drew before class, or by laying their sun tracker on the ground against a compass that is aligned to north.





The shadow of the pen's tip must fall where the lines cross under the bowl.

7. Once their sun tracker is correctly lined up with north, the shadow of the tip of a transparency pen can be lined up with the crosshairs in the center of the piece of paper. Keeping the shadow of the pen tip on the cross hairs, they must then lower the pen until it is touching the plastic bowl and make a small dot. They will then label the dot with the exact time and date. This dot represents the position of the sun in the sky if the student were standing on the crosshairs under the plastic bowl.
8. Tell the students they will need to come back to this exact spot with their sun tracker at least three more times today to take data points that are a minimum of 30 minutes apart. Tell the students they should also take at least one measurement tomorrow morning before class.
9. Return to the classroom to introduce the topic of solar energy, or hold class outside, if possible, to use the sun's energy as a demonstration.

IV. Activity Two: Solar Energy Applications — 20 minutes

<u>Objectives</u>:

a) TLW discover how solar energy can best be captured and used.
b) TLW understand the difference between passive and active solar systems.

<u>Materials</u>:

For the class: a slide show of images as described in step one below; a computer, a screen, and a projector; several passive and active solar energy collectors (such as an evacuated tube solar

collector, a photovoltaic cell, super-insulated windows, solar tube lights, etc.) borrowed from a solar energy supplier or installer.

Procedure:

1. You may want to have a representative from a home energy or solar energy company come in to talk to your students about active and passive solar energy applications. They will be able to bring in collectors for hot water and for electricity and show pictures of how the systems are used in residences and businesses. If you do not have a guest speaker, you can create a slide show of images that illustrate how solar energy is applied in passive and active forms. Following are some pictures you'll want to collect for the slide show. For passive solar energy: south-facing windows with blinds; a diagram of triple-glazed super-insulated glass; greenhouses; greenhouses attached to houses; black water barrels or stone flooring to act as thermal mass that heats during the day and radiates during the night; solar tube lights; sky lights; roof eves long enough to block summer sun and short enough to maximize winter sun; a solar oven; etc. For active solar energy: a diagram of an enveloped house; a flat-panel solar hot water heater installed on or next to a house; an evacuated tube solar collector and an assembly of tubes set up to heat water for a house; a solar pond and a diagram of how it works; a diagram of a photovoltaic (PV) cell; a PV panel or a PV array that is free-standing or mounted on a building.
2. Relate what the students did in Activity One to the concepts in solar energy collection by asking questions that generate a discussion:
    a. How does the position of the sun affect how and when a person can use solar energy? *(The amount of energy available differs with the location on earth, the season, the angle of the device being used and the direction the device is facing.)*
    b. What parts of the world have the maximum amount of solar energy available for collection? *(Places near to the equator, places with clear weather, and places with little vegetation to block collectors.)*
    c. What can you do to collect solar energy in places that do not have the maximum solar gain? *(Collectors can be angled toward the sun or can be moved to track the sun's movement.)*
    d. What is the difference between passive solar and active solar? *(Active solar involves a motor, pump or other mechanical device.)*
    e. What types of benefits can be obtained from solar energy? *(Light, heat, ventilation, electricity, hot water, cooking fuel, etc.)*
3. Introduce some passive ways to gain heat, light or ventilation using solar energy. Use the slide show of images you collected to explain the concepts of passive solar energy use. Explain how solar gain can be regulated with fans, compartmentalization and other techniques. For instance, a greenhouse with sliding doors can be attached to the daytime living area of a house to let in light and heat in the winter. If the

greenhouse is able to absorb heat (for example, if the floor is made of slate stones, or if there are water barrels in the greenhouse, or a rock wall) it can radiate the heat into the house all night, when the sun is down. If the greenhouse gets too hot during the day or too cold during the night, the room can be closed off.

4. Be sure to remind the students that often during the summer, heat and light are unwanted in the amount available and so there are heat and light reducing designs as well (roof eves; smaller, south-facing windows; plants positioned to grow over windows/greenhouses/patios/roofs; awnings, shutters and louvered windows; mature deciduous trees on the south side of a house that block out sun with summer foliage and allow light and heat during the winter when they are bare).
5. Introduce how active solar systems work, starting with the least complicated concepts (solar hot water heating, an enveloped house with a basement and fans to circulate air, solar ponds, etc.).
6. Explain how a photovoltaic cell is able to convert solar radiation into electricity. Show students what PV panels and arrays look like (they may recall having seen these devices used to light up billboards or power emergency phones, etc.).
7. Remind the students about their EcoHome project. Ask them if they will need to maximize or minimize light and heat in their particular location. Ask the students which passive and active solar energy devices and uses might be right for their particular project.

HW: Ask the students to each design a solar oven—an oven that, instead of using electricity for cooking, uses heat from the sun. Tell them they will work in pairs (or lab groups) tomorrow to create an oven they feel offers the best original design. Inform the students that a one-liter bottle of water will be placed in each oven and the water temperatures will be compared after all the ovens have been in the sun for the same amount of time. (The oven whose water temperature is highest will be awarded a prize.) Each oven's design must therefore feature an interior space large enough to hold a one-liter water bottle.

HW: Remind the students to prepare for a reading quiz on Ch. 10 of *When Smoke Ran Like Water*.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 19

I. Topic: **Solar Energy**

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: Take the quiz for Ch. 10 of the Devra Davis book. Turn the quiz over on your desk when you are finished.

III. Activity One: ***When Smoke Ran Like Water*** **- Ch. 10 Quiz** **15 minutes**

Objectives:

a) TLW demonstrate what they have retained from the Davis book.
b) TLW express and generate interest in the book they are reading.
c) TLW make connections between the examples given in the Davis book and what they are learning in their textbook and class.

Materials:

For each student: one copy of the quiz.

Procedure:

1. Allow the students 5-6 minutes to complete the reading quiz.
2. Ask the students to trade papers with someone who has a different color pen.
3. Go over each question, allowing the students to provide answers and discuss the book in order to build interest in it and make connections to topics covered in the textbook and in class.

IV. Activity Two: Build a Solar Oven **35 minutes**

Objectives:

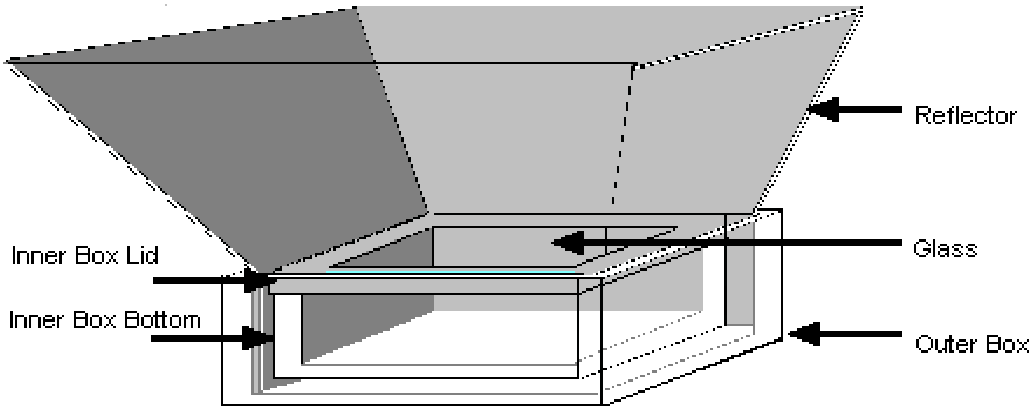
a) TLW apply the concepts of passive solar energy collection to an oven they design themselves.
b) TLW discover how their oven performs compared to others.

Materials:

For each pair of students or lab group: 1-2 used cardboard boxes large enough to hold a 1-liter water bottle (the boxes can be bigger than that, but not smaller); a roll of duct tape; a carpet-cutting knife or serrated kitchen knife; a sturdy pair of scissors; a roll of aluminum foil; one thermometer; a 32-oz. plastic water bottle (all the lab groups' water bottles must be the same, for testing purposes); and a piece of glass or plastic that is large enough to completely cover the opening of the box. (If possible, ask the school's maintenance staff if they could save window panes from old windows for you, so that each of your lab groups (now or in your future classes) has a single piece of glass to use. Put duct tape around the edges of the panes, to prevent cuts, and save the panes for reuse each year. You could also call salvage shops and construction sites to find old panes.) For the class: black construction paper; and various types of insulating materials (you may want to collect these items throughout the year, so that no new materials are used in future classes)—old boxes, packing peanuts, 1-1.3-foot home insulating board, "Great Stuff," old Styrofoam ice chests, air pack bags, bubble wrap, corrugated cardboard boxes, etc; and a copy of Free Response question #1 from the 2006 APES Exam (which can be obtained from www.apcentral.collegeboard.com), to be assigned as homework, below.

Procedure:

1. Allow the students a few minutes to confer with their partner or lab group about the ideal solar oven design, sharing their homework from last night. Some groups may want to nest boxes one inside the other as an insulated design, other groups will build insulation into a single box. The flaps that open on the top of the box can be covered in aluminum foil and used as collection panels. Additional collection area can be added with additional pieces of cardboard. Browse the Internet for other design ideas if you have never seen a solar oven, or look at the diagram below for a general design idea. Encourage your students to optimize the angle of the sun and balance the collection performance with the heat retention performance. Even a small leak will translate to significant heat loss, so all cracks must be sealed. Outside surfaces should be reflective, while inside surfaces are best kept dark. Remind them that the ovens will be outside, so they will need to be stable in a breeze.



2. Give each group the supplies from the Materials list above and allow each group to pick out the box or boxes they want to use.
3. Give the students the rest of the class period to build the ideal solar oven.
4. Allow the students to take their projects home to complete them, if necessary, or allow them time to return to your lab after class, to complete their ovens or perfect their designs.
5. You will need to identify a day and time when the ovens can be tested. When all the ovens are ready, give each group a filled 32-oz. plastic water bottle—with the label removed—and have the students set up their ovens outside, in a location where they will not be disturbed. Allow the students to visit their ovens in between classes, if they want to turn them as the sun moves or check that they haven't blown over. At a set time between 1:00 and 2:00pm, which is when they should be hottest, open all the ovens, swirl the water and place a thermometer into each bottle. Ask the students to read the temperature of the water after the thermometer has been sitting in the water for 2 minutes.

HW: Ask the students to write an essay for Free Response question #1 of the 2006 APES Exam.

When Smoke Ran Like Water by Devra Davis
Ch. 10 - "Defiant Figures"

1. From what historical monument does Davis get the phrase "defiant figures" for her last chapter?

2. Who does Davis describe as the defiant figures of today's world?

3. Why does Davis say it is surprising "not how little we know about public health today, but how much we have been able to learn"?

4. Describe what steps the auto manufacturer mentioned in Ch. 10 has taken to reduce their pollution and environmental impact.

5. Why does Davis mention the starfish story in the final paragraph of this book?

When Smoke Ran Like Water by Devra Davis
Ch. 10 - "Defiant Figures"

1. From what historical monument does Davis get the phrase "defiant figures" for her last chapter? *The monument at the Nazi prison camp, Dachau, where the prisoner has his head upright, staring straight ahead with an unyielding expression.*

2. Who does Davis describe as the defiant figures of today's world? *The people who are doing what seems natural, decent and inoffensive, pursuing their work or seeking to discover something true and useful—in other words, the scientists who are revealing information that is not well-received by people, committees and companies who do not want to know this information.*

3. Why does Davis say it is surprising "not how little we know about public health today, but how much we have been able to learn"? *Because of "the barriers to science, the outright lying and deception and intimidation, and the political and economic pressures that continue to make it difficult to conduct studies at all."*

4. Describe what steps the auto manufacturer mentioned in Ch. 10 has taken to reduce their pollution and environmental impact. *Ford Motor Company tore down a plant in Dearborn, Michigan to build an energy-efficient plant with on-site wetlands to deal with water treatment.*

5. Why does Davis mention the starfish story in the final paragraph of this book? *Though the environmental problems we are facing today seem huge and insurmountable, she points out that, like the man who throws starfish back into the sea, making even a small contribution can have a significant impact on those immediately affected.*

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 20 - Extended Lab Period

I. Topic: "Green" Buildings Field Trip

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Get ready to go on the green buildings field trip. Bring a pen, notebook (or paper and something firm on which to write) and your completed essay from last night's homework.

III. Activity One: Grade a FR Essay on the Bus 10 minutes

Objectives:

a) TLW grade FR essays to see how the details and facts included in the essay compare to those in the grading rubric.
b) TLW see how their work compares to their peers' and to the grading rubric.

Materials:

Each student will need their completed essay for FR question #1 from the 2006 APES Exam; a pen of another color; and one copy of the grading rubric for the essay, which can be obtained from the www.apcentral.collegeboard.com website.

Procedure:

1. When the students board the bus for the field trip, ask them to pass in their Free Response essays. Redistribute the essays, making sure that no one is grading their own paper.
2. Ask the students to go over the grading rubric before they begin grading.
3. While grading, the students are to write points earned in the left-hand margin of the paper and underline the word, phrase or sentence that earned the points.
4. When they have finished, ask the students to add up the points earned, write the final grade at the top of the paper and their name at the bottom of the paper, and turn it in for recording.

IV. Activity Two: "Green" Buildings Field Trip 1-4 hours

Objectives:

a) TLW observe sustainable technologies being used in businesses and residences.
b) TLW develop an idea of how to incorporate solutions for certain problems into their EcoHome project.
c) TLW hear firsthand from builders the pros and cons of different building choices.

Materials:

For each student: one copy of the "Green Buildings Field Trip Questions" handout.

Procedure:

1. Prior to class, search for companies and private homeowners in your area who have chosen to build or renovate using environmentally sustainable methods. You may want to start with the Green Builder directory at http://www.greenbuilder.com. Enter your city and state to find builders in your area or use the Building Green website to look for certified green building structures: http://www.buildinggreen.com/hpb/. (Or, search the Internet for another green building directory, if the ones mentioned here do not offer the information you need). Once you have located a builder in your area, call or email them. Let them know that you are teaching your students about sustainable building techniques and are looking for places the class can tour, to see structures or technologies that have a lower resource and energy impact on the earth. You can ask the builder if they know of any strawbale, earthship, earthbag, cob, rammed earth or cordwood houses in your area (to familiarize yourself with some of these building methods, go to http://www.greenhomebuilding.com). Often, people who build their houses in one of these styles do not use a building company, but a green builder might know people who have built such houses and be able to give you their contact information. Even if the people who live in these homes or buildings are not comfortable hosting a tour, they may point you to another homeowner who would be. People who live and work in environmentally sustainable structures are often well-informed and eager to teach others about the most current technology, the start-up costs, the efficiency and the pros and cons of certain technologies, building methods and sustainable choices. In addition, green building tours may lead your classes to discover new resources, books and related topics such as information on reducing sick-building syndrome (using zero-VOC finishes, floor coverings and paints; no-vent heating and cooling, etc.) or tax deductions for sustainable systems, the use of permaculture, etc.
2. If possible, allow time after the field trip for your students to discuss what they have seen. This will help you verify whether they understood certain

concepts and enable you to discover what building techniques or features particularly impressed them.

HW: Ask the students to bring in the final draft of their floor plans for their EcoHome Project. You should check all the floor plans before any EcoHome projects are completed in case you need to ask a student to revise or alter their model in any significant way. If you are concerned that some students may be procrastinating, ask them to finish building their model this weekend and assign a day for them to bring it to class, before it will be presented.

Green Buildings
Field Trip Questions

1. Describe how each of the buildings you visited dealt with heating interior air during the colder months.

2. Of the heating techniques you observed, which did you prefer and why?

3. Describe how each of the buildings you visited dealt with cooling interior air during the warmer months.

4. Of the cooling techniques you observed, which did you prefer and why?

5. Describe how each of the buildings you visited dealt with insulating the building.

6. Of the insulating techniques you observed, which did you prefer and why?

7. Describe how each of the buildings you visited dealt with obtaining clean water.

8. Of the water system techniques you observed, which did you prefer and why?

9. Describe how each of the buildings you visited dealt with heating their

water.

10. Of the water-heating techniques you observed, which did you prefer and why?

11. Describe how each of the buildings you visited dealt with treating sewage.

12. Of the sewage-treating techniques you observed, which did you prefer and why?

13. Describe how each of the buildings you visited dealt with lighting the interior spaces during the day.

14. Of the lighting techniques you observed, which did you prefer and why?

15. Describe how each of the buildings you visited dealt with electricity demands.

16. Of the electricity-generating techniques you observed, which did you prefer and why?

17. Describe how each of the buildings you visited dealt with the waste they produced.

18. Of the waste management techniques you observed, which did you prefer and why?

19. Describe how each of the buildings you visited dealt with landscaping.

20. Of the landscaping techniques you observed, which did you prefer and why?

21. Use the space below to describe five other things you found interesting:
    a.
    b.
    c.
    d.
    e.

22. Describe one thing you found to be inspiring:

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 21

I. Topic: Wind Energy

II. Warm-up: **5 minutes** Prior to class, write the following on the board: Based on what you have seen at the coal-fired power plant and the hydroelectric power plant, draw a diagram of how you think a wind turbine works. *(Be ready to show on an overhead projector the wind turbine diagram that follows this lesson plan, so that the class can check their ideas against it.)*

III. Activity One: Build a Wind Turbine **45 minutes**

Objectives:

a) TLW explore different wind turbine designs.
b) TLW discover that wind turbine design differs depending on the objectives for a particular region or use.

Materials:

It is recommended that you use the "PicoTurbine Windmill Plans and Experiments" handout from the www.catalystlearningcurricula.com website (see step 1 below). Obtain the supplies listed on the handout (or, purchase a kit from the PicoTurbine website at www.picoturbine.com), so the students can build a wind turbine that functions well and houses a generator.

If you choose to ask your students to design their own turbine without a generator, have items such as the following available for use: scissors; cardstock paper; tape; glue; plastic or paper drinking cups; pipe cleaners; wire; wooden dowels; metal brads and any other supplies that can be used to build a turbine model.

Procedure:

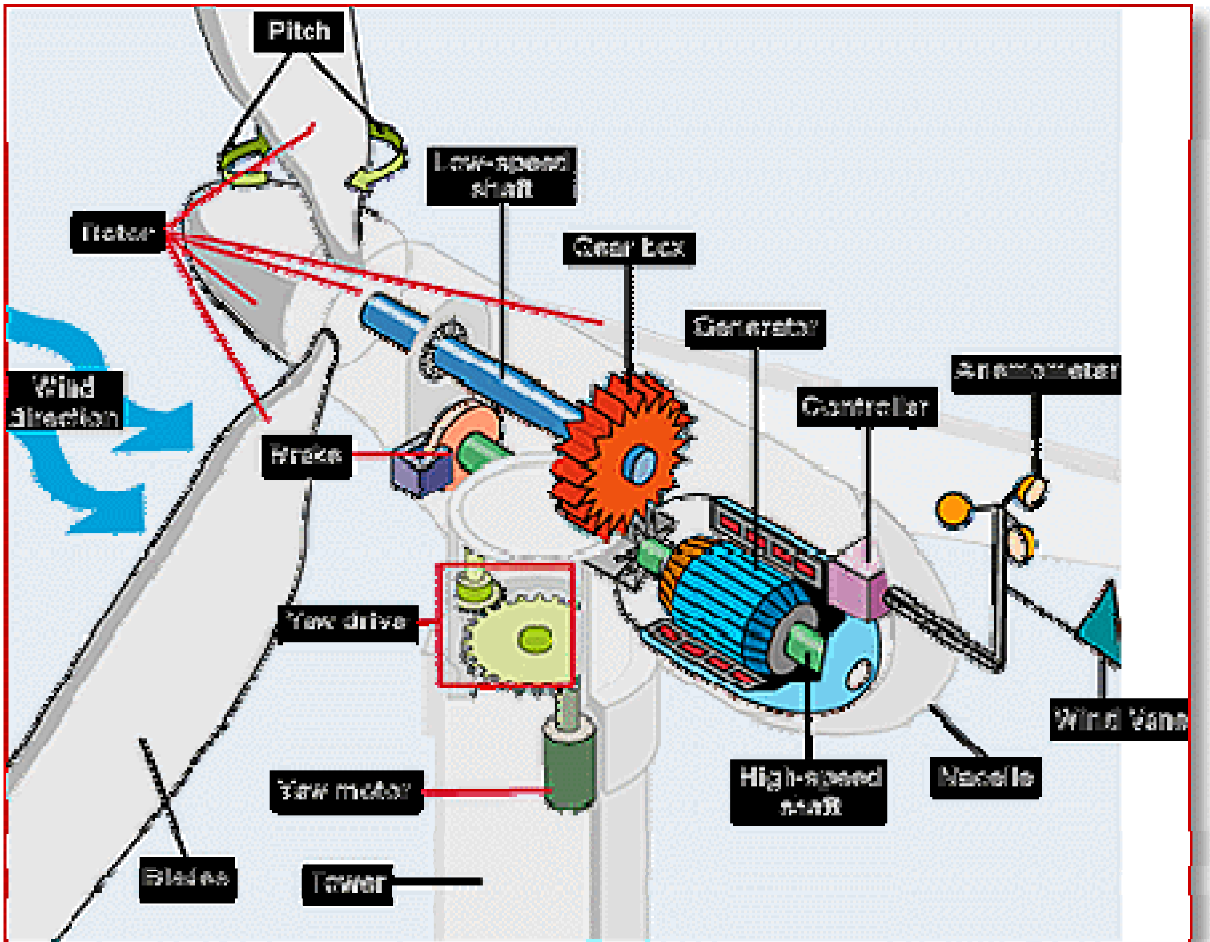
1. Prior to class, go to the AP Environmental Science curriculum page at http://www.catalystlearningcurricula.com/curric_apEnviro.php to download the "PicoTurbine Windmill Plans and Experiments" instructions. You can use these instructions, or you may choose to allow your students to design their own wind turbine, based on their own research or ideas.

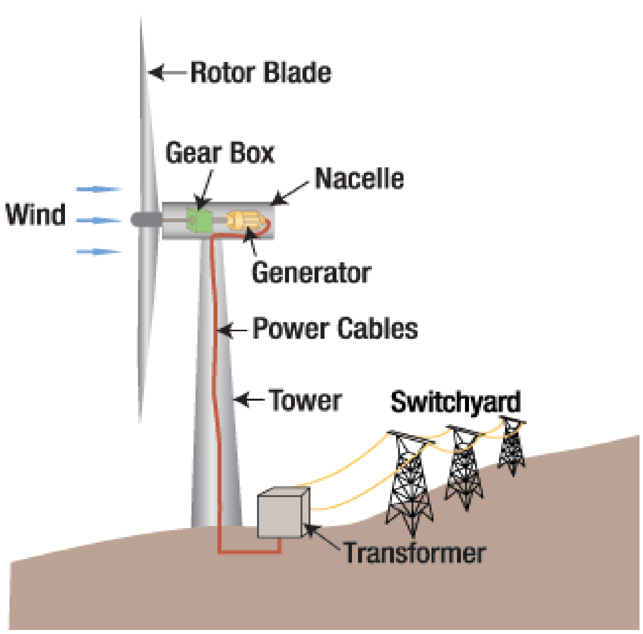
2. Begin by going over the warm-up to check that the students understand how wind can be converted into electricity. Ask the students what other blade shapes or designs could be used to catch wind. Ask the students how the amount of wind an area receives (maximum peak wind speed and duration) influence the design of the turbine.
3. Ask the class to work in pairs to create a working wind catcher or PicoTurbine. At the very minimum, the model built must spin with a breeze. Tell the students that they will be working for prizes in each of the following categories (they can design a method to test the winner in each category):
    a. The design that spins the fastest in the least amount of wind.
    b. The design that can continue to spin in the strongest wind.
    c. Optional: The design that can produce the greatest mechanical force. (This would be difficult to test, however if your students have the time and interest, it's an interesting subject to study since windmills have historically been used to grind grain, crush sugar cane, pump water, or perform some other mechanical work.)
4. Allow the students to explore different design possibilities, using the materials you've supplied. Remind them that failures are very educational, as are second tries.
5. The students will very likely need additional time to work on their models and to perfect their design. Set a time at which the models will be tested in the above-mentioned categories.
6. Leave time to discuss with the students what they would do to improve even the best designs if they had more time and unlimited resources.

HW: Ask the students to finish building their wind turbines and have them ready to compete by __________.

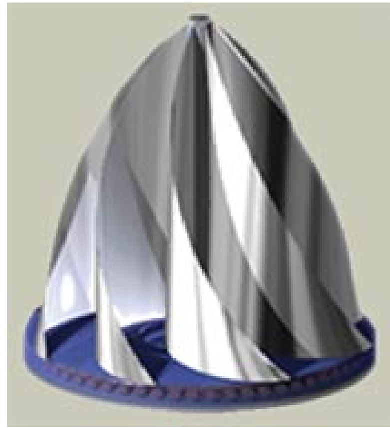
HW: Ask the students to draw diagrams of a natural gas-fired power plant, a nuclear power plant, a hydroelectric power plant and a wind generator. Ask them to label all of the diagrams and explain what these electricity-generating stations have in common and how they differ.

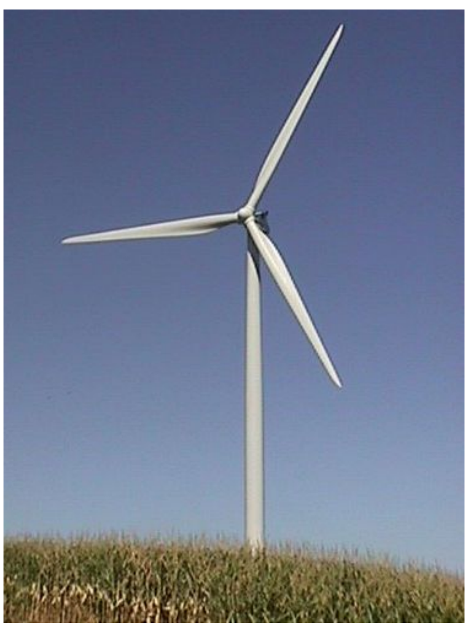
Diagram of a Wind Turbine





Wind Turbine Designs





For more photos and information on design pros and cons, go to: http://www.windpower.org/en/tour/design/index.htm.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 22

I. Topic: Wind Energy

II. Warm-up: **5 minutes** Prior to class, write the following on the board: Describe how you plan to meet the electricity needs of your EcoHome. Be specific in your description (how many solar panels, how many wind turbines, etc.).

III. Activity One: Energy Production Calculations 45 minutes

Objectives:

a) TLW perform the calculations necessary to determine exactly how the energy demands of their EcoHome will be covered.
b) TLW weigh electricity production options and choose the method best suited for their particular needs.

Materials:

For each student: one calculator; and one copy of the "Covering Our Energy Demands" handout. For each student or pair of students: one computer with Internet access.

Procedure:

1. Distribute the "Covering Our Energy Demands" handout.
2. Ask the students to choose only one type of technology to meet their energy needs when they design their EcoHome. Let them know that they may want to use a grid-tie-in system, in which their home would be hooked up to the local energy supplier and all surplus "green" energy generated by their home would be sold back to the power company for profit (conversely, if their own energy production system were ever to fail, they'd be able to get electricity from the power company).
3. Ask the students if they can think of other reasons why using a grid-tie-in system is a win-win situation for the homeowner and the power company? *(In addition to the above-mentioned benefits, this set-up allows the power company to reduce their use of fossil fuels, it enables other families to buy green power, and it keeps the homeowner from having to buy or use batteries, which are expensive, require frequent replacement and are environmentally costly. Also, most alternative energy systems produce an excess of power during some periods of the day or year and less power at other times. A grid-tie-in system allows the homeowner to set up a*

system that produces an average amount of electricity rather than an overly large system to cover the extreme highs and lows.)

4. Begin a discussion about the differences between using one power source compared to another. Ask the students what persuaded them to choose one type of power source over another. Explore their feelings and biases toward the various systems. Ask them how big a role economics played in their power supply decision. Ask them what role location and regional availability of resources played in their decision.

HW: Ask the students to continue working on their EcoHome project.

Covering Our Energy Demands

1. What are your current kilowatt-hour per month electricity demands (use the information calculated on Day 5 of this unit):___________kilowatt-hrs./month

2. How much electricity do you estimate you will need each month for your EcoHome? ________________kilowatt-hrs./month

If the number of kilowatt-hrs. per month you have calculated is higher than the 250 kilowatt-hrs. per month listed on the chart below, you will have to either research the amount of money it would cost to upgrade the system you intend to use on your EcoHome to cover the cost of the difference, or find ways to lower your kilowatt-hrs. per month demand.

	Solar Energy	**Wind Energy**	**Hydro Energy**
Approximate startup cost for a system producing 250 kilowatt-hrs. per month	~$20,000	~$17,000	~$11,000
Approximate cost of upgrading this system to cover my electricity demands			

Fill out a. or b. according to what you chose to do:

a. How much will it cost to upgrade the system you think you will use?

b. How do you plan to decrease your total demand?

Research the federal and state tax incentives that are in place for each type of electricity generating system. Fill in the chart below with the information you find. Here are some websites that will help you find the information you need:

Go to the Energy Star website http://www.energystar.gov/ and search the site for "tax incentives" to learn about federal tax rebates.

Go to the Database of State Incentives for Renewables and Efficiency website http://www.dsireusa.org/ and click on your state to learn about state tax incentives.

	Solar Energy	Wind Energy	Hydro Energy
Federal rebates for using this type of system			
State rebates for using this type of system			

3. Considering all that you have learned about the pros and cons of each type of electricity generation, the financial incentives, costs and usefulness in the area where your EcoHome is located, what source of electricity generation will you use for your EcoHome?

4. Explain the reasons you have chosen this type of system.

5. How much will the system you have selected cost before tax rebates?

6. How much will the system cost after federal and state tax rebates?

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 23

I. Topics: Geothermal Energy

II. Warm-up: 5 minutes

Prior to class, write the following on the board: What do you think is the most comfortable temperature for your house during the summer and during the winter? Does this ideal interior temperature change during the night and during the day?

III. Activity One: Geothermal Energy 5 minutes

Objectives:

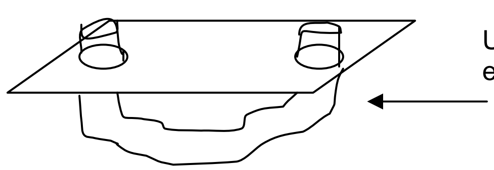
a) TLW create a simple model of a geothermal system.
b) TLW decide on the best method for heating and cooling their EcoHome, based on the abiotic factors in their location.

Materials:

For the class: one piece of foam-core board; a stapler; several twist ties (used on garbage bags and loaves of bread); one meter of thin flexible plastic tubing (such as the type used for aquarium aeration); 50cm of flexible plastic tubing that is 3cm (1 1/4-inch interior diameter); and an Exacto knife or a sharp pair of scissors.

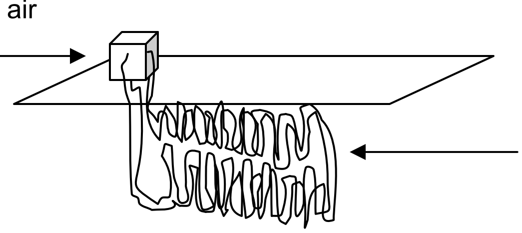
Procedure:

1. Prior to class, make two models of geothermal heating and cooling systems: Cut the foam-core board in half to make two roughly square pieces. For the first model, “earthtubes,” imagine that the foam-core board is the floor of a house. Now take one of the board halves and cut two holes—opposite each other, near the edges of the board—that have the same diameter as the larger-diameter (1 1/4”) plastic tubing. Push the ends of the tubing up through the holes, such that each tube end sticks out about 3-4cm. Use twist ties to hold the tube ends in place.



This model illustrates how earthtubes are placed in the floor of a house. The tubes are buried under the house and the air in the tubes is cooler than the air in the house. Fans can be placed on either end of the tubes to circulate the cool air with the warmer air in the house. In the winter, the air in the tubes will be warmer than the air in the house if the house is unheated. The air in the tubes helps maintain a constant temperature in the house, due to the more even air temperature under the house.

2. To create the second (greatly improved) model—a geothermal heat pump—cut two small holes about 4cm apart in the remaining square of foam-core board. The holes should be large enough for the remaining, thinner piece of tubing to fit through. Thread one end of the smaller tubing through the first hole and the other end of the tubing through the second hole, such that most of the tubing is hanging down under the board. Again, the foam-core board represents the floor of the house, but in this model, the tube contains fluid that has a high heat capacity. The fluid will circulate in the tubing, which will be coiled in the ground to gain or lose the heat (from the ground's temperature) necessary to maintain an even temperature in the house. The tube can be stapled against a small piece of cardboard in zigzagging coils and put under a model of a house. You can represent the underground space with a large bowl of ice (so the students can see through the solid) or sand, or you can leave both models out on your desk and explain their relationship with the ground.



3. Begin by discussing the warm-up. Everyone will have different preferences regarding indoor air temperature, but you want to make the point that indoor air often needs to be adjusted with seasonal changes in temperature and humidity.
4. Discuss the inefficiency of using electric (or resistance) heating. You can point out how many transformations the energy must go through—from burning a fuel to blowing hot air across a hot wire—and point out to the class the energy loss at each step along the way. Explain the concepts behind heat pumps and furnaces. Point out the energy losses that occur with each.
5. Ask the students if they can think of a more direct approach to heating and cooling. Take time to discuss wood stoves, fireplaces, windows and fans, evaporative coolers and other devices they may mention.
6. Ask the students what the temperature of the earth is 10 feet under the surface? *(The temperature remains fairly constant underground, about 10°-18°C year round.)*

7. Show the students the two models you've created, explaining how the tubes use the consistent underground temperature to regulate seasonal fluctuations in temperature inside the house. Explain that the second model requires a heat pump for either forced air heating and cooling or a radiant floor heating system, while the earthtubes require only a fan.
8. To check how well your students understand the efficiency of these heating and cooling methods, ask them to calculate how many degrees they would have to lower the temperature to get cool enough in the summer. Ask the students how many degrees they would have to raise the temperature to stay warm enough during the winter.
9. Ask your students how they plan to heat and cool their EcoHomes. How many degrees will they need to change the temperature for each season? What heating and cooling choices do they have for their climate? (For example, evaporative coolers are very efficient in dry regions but do not work well where humidity is high; louvered windows work well for windy areas, etc.)

IV. Activity Two: Wave and Tidal Energy 10 minutes

Objectives:

a) TLW become familiar with the potential electricity generation that is available in wave and tidal energy.
b) TLW propose some techniques that could be used to harness this energy.

Materials:

For each student: 2-4 sheets of blank copy paper. For each lab group: one poster board.

Procedure:

1. Begin by asking the students what they know about wave and tidal energy:
   a. What is the source of tidal energy? *(Gravitational pull of the earth's sun and moon.)*
   b. What is the source of wave energy? *(Waves occur from ocean currents colliding with land masses. Ocean currents are caused by wind currents. Wind currents are caused by the unequal heating and cooling of the earth's surface. Unequal heating and cooling is due to solar radiation.)*
   c. How much energy do you think is available in tides and waves (for instance, compared to nuclear energy, wind energy and hydro power)? Do you think the energy would flow steadily, be erratic or be cyclical? Is the energy a high net yield or a low net yield?
   d. How dependable are these sources? *(Fairly dependable, however storms will interrupt power.)*
   e. Where can wave energy be found? *(Shores that have a strong wind-produced current that are not enclosed by protective land masses.)* Where can tidal energy be found? *(Steep shores where the height*

differences between high and low tide are greater; places further north or south of the equator, where the moon's pull on global water has a more dramatic effect.)

2. Ask the students to divide into lab groups and design a method for capturing either wave or tidal energy.
3. Ask each group to present their best idea(s) to the class for peer review before the class period is over.
4. After all the groups have presented their ideas, ask the class to discuss any limitations or difficulties that needed to be addressed. Ask them what features they all tried to optimize in their designs.
5. Remind the students that they may want to include wave or tidal power in their EcoHome project if they are near a coast with high energy potential.

HW: Ask each student to bring in an environmental science-related book that they plan to read for the last part of the school year now that they have finished the two required-reading books (by Mark Plotkin and Devra Davis). Tell them that they must have read at least the first chapter before class tomorrow.

HW: Ask the students to continue working on their EcoHome model, floor plans and worksheets.

AP* Environmental Science
Daily Lesson Plans
Resources and Energy Unit

Day 24

I. Topic: Hydrogen Energy

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: Why would hydrogen seem to be a wonderful source of energy? *(It combines with oxygen—which is readily available—to produce water, which is non-polluting.)* What are the problems with using hydrogen for power? *(Hydrogen is not found alone in nature so it must be generated and stored as a metal hydride or as a gas. This process of generating pure hydrogen gas or a metal hydride takes an enormous amount of energy. Hydrogen gas is dangerous to store because it's flammable.)*

III. Activity One: Hydrogen Fuel Cells **25 minutes**

Objectives:

a) TLW understand hydrogen energy generation and by-products.
b) TLW consider solar energy research and development as a model for the future of hydrogen energy.

Materials:

For the class: hydrogen fuel cell model, if possible.

Procedure:

1. Ask the class to tell you the difference between hydrogen energy and hydroelectric energy.
2. Write the following equation on the board: $H_{2(g)} + O_{2(g)} = H_2O$ + energy
3. Discuss the warm-up questions. The students' answers to these questions will tell you what they do and don't understand about this energy source.
4. Draw a diagram or use a purchased model to explain how hydrogen can be used for mechanical and electrical energy.
5. Ask your students if they can think of a way in which hydrogen energy could be generated in a clean, sustainable manner. *(If hydrogen gas were isolated through a hydrolysis reaction using solar energy, then the stored hydrogen could be used as a mechanical or electrical energy source that produces no pollution.)*
6. Ask your students how hydrogen energy could be applied if it became readily available. *(It could be used for electricity, to power mechanical devices, for heating and cooling, to power cars and other forms of transportation, etc.)*

7. Explain to your students that hydrogen power is in its infancy in much the same way that solar power was 50 years ago. Hydrogen technology is still being explored. Hydrogen fuel cells are too expensive to use on a large scale. The isolation of hydrogen gas is still not practical because it requires an enormous amount of energy. Hydrogen as a fuel would only be sustainable if the energy needed to isolate hydrogen gas came from a solar energy power station. However, solar energy is now affordable for both small- and large-scale applications and this may become true for hydrogen power as well. Great minds are being put to the task of working out the problems and limitations associated with hydrogen power. Remind the students that solutions come much faster now that issues are commonly addressed by the global scientific community (rather than isolated groups).

IV. Activity Two: Environmental Science Book Share 20 minutes

Objectives:

a) TLW be introduced to other interesting books on environmental science topics.

Materials:

Each student will need the book they have chosen.

Procedure:

1. Prior to class, all students will need to read the first chapter or two of the book they have chosen so they can present the book to their peers.
2. Ask each student to describe what their book is about and what made them choose the book.
3. After all the books have been introduced, ask the students if anyone would like to swap books with another person or change the book they have chosen before they continue reading.
4. Ask the students to make a plan for reading their selected book during the time that remains before the APES Exam. They should take the total number of chapters and divide it by five to get an idea of how many chapters they need to read each week. Help the students by asking them to write down their reading goals for each week and turn it in to you. You can remind the students of these goals if they start to fall behind.

HW: Ask the students to complete their EcoHome projects and bring their models, floor plans and worksheets to class tomorrow for presentation.

Day 25 - Extended Lab Period

I. Topic: Learning Assessment: Resources and Energy Topics

II. Warm-up:

Prior to class, write the following on the board: Prepare to present your EcoHome project to the class.

III. Activity One: EcoHome Project Presentations 90 minutes

Objectives:

a) TLW test their knowledge of resources and energy vocabulary and concepts.
b) TLW get practice applying what they have learned to a situation they may one day face.

Materials:

Each student will need their EcoHome model and the accompanying papers that summarize their project.

Procedure:

1. Write the following questions on the board or on an overhead transparency for the class to see:

- Where is your home located? What abiotic factors are important to take into consideration at this home site?
- What type of materials would you use to build your house? Explain why you chose these materials and how they are sustainable.
- How will you meet your electricity needs sustainably?
- How will you meet your fresh water needs sustainably?
- How will you meet your hot water needs sustainably?
- How will you meet your home heating needs sustainably?
- How will you meet your home cooling needs sustainably?
- How will you prepare food sustainably (obtain food, store food, cook food, dispose of food waste)?
- How will you deal will your grey (non-sewage) wastewater sustainably?
- How will you deal will your sewage water sustainably?
- Explain anything else about your project that you've included (interior furnishings,

transportation to and from your home, etc.).

2. Ask the students to each present their project to the class, addressing the above questions as they give their presentation. Be sure to ask the student any question they have overlooked.
3. It would be a good idea to take notes during each student's presentation, in case the student explains something about their project that does not appear in their summary paperwork.
4. After all the projects have been presented and graded, you might ask the class to pick the best projects to put on display. In order to better focus their choices on the objectives of the project, you may want to introduce a few categories such as: the project that has the lowest environmental impact, the project that incorporates the most modern "green" technology, etc.

HW: Remind the students that they must watch *The Power of Community: How Cuba Survived Peak Oil* by tomorrow's class period.